Accumulations of Nutrients in Corn Soil as Influenced by Poultry Litter Application Rate

R.A. Gilfillen, W.T. Willian, and H. Henderson
Western Kentucky University
Department of Agriculture

ABSTRACT

Poultry litter can be a valuable resource when applied at rates required by a given crop. However, nutrients being present in higher concentrations than needed, or not available when needed, are obvious concerns for producers when using poultry litter as a fertilizer. During 2001-03, silage corn plots were established under no-till and conventional till conditions with three fertility treatments superimposed over the tillage treatments. The fertility treatments were (1) ½ rate of poultry litter at N rate and ½ inorganic N, (2) poultry litter applied at the N rate, and (3) inorganic fertilizers. Soil samples were taken from 0-15 cm prior to planting, at mid-season, and at corn harvest. The harvest soil samples were analyzed for nutrient content and comparisons are as follows. Over the three year observation, very few differences were seen between tillage treatments. Interactions existed between tillage and fertility for available Mg and Cu, along with organic matter and CEC. Differences were observed between fertility treatments in the following measurements: water pH, available P, K, Zn and ortho-phosphate content. Water pH was greater in treatments receiving poultry litter than inorganic fertilizers alone. Available P and Zn were higher in treatment 2 than 3. Available K was higher in treatment 2 than either 1 or 3. Ortho-phosphate content was greater in treatment 2 than in 3. Indications are that poultry litter applied at the N rate resulted in excess levels of available P, K, Zn, and ortho-phosphate in comparison to the inorganic fertilizers.

INTRODUCTION

Poultry production in Kentucky has increased by 2.5 times from 1997 to 2002 (KASS, 2004). Most of the production is located in 4 western counties of the state, which gives limited land area for poultry waste application. Similar to other poultry producing areas, excess poultry litter application can lead to nutrient accumulations in soil and water pollution (Lander et al., 1998).

Excess application of poultry litter can negatively impact water quality via runoff and groundwater contamination after application (Kingery et al., 1994, Edwards & Daniel, 1993, and Sharpley et al., 1993). A 4.5 Mg ha^{-1} rate resulted in significantly higher N & P concentrations in runoff (Sauer et al., 2000). Sharpley and Moyer (2000) also found that 20% of total P was lost after just 5 rainfall events.

Poultry litter is deemed an excellent nutrient source due in part to being inexpensive. When broiler litter is applied to meet crop N requirements, this can lead to 6x (Kingery et al., 1994) to 8x (Franzluebbers et al., 2002) as much P as needed. In turn long term application of litter can lead to soil nutrient imbalances (Sistani et al., 2004). Kingery et al. (1994) found accumulations of NO_3-N, along with extractable P, K, Ca, Mg, Cu, and Zn up to 60 cm of depth. Wood et al.

(1996) found accumulations of C, P, K, Ca, Mg, Cu, and Zn after litter application to corn fields. Increased surface N, C, K, and P content were seen in no-till cotton fields after litter application (Sistani et al., 2004). Soils that were amended with poultry litter for 25 years have shown excess accumulations of Cu and Zn (Han et al., 2000).

The first purpose of this study was to determine if soil nutrients are accumulating at a higher amount due to the three fertility treatments. The second purpose was to observe if differences existed in soil nutrient accumulation based on two different tillage systems in corn soils.

MATERIALS & METHODS

This study was conducted at the Agricultural Research and Education Center in Bowling Green, KY. Soil type is a Pembroke silt loam (Mollic Paleudalf) on a 0-1% slope. Soil samples were taken to a depth of 15 cm at planting, midseason, and harvest.

Soil fertility treatments consisted of an N rate of poultry litter (NPL), a ½ rate of poultry litter + ½ rate of inorganic fertilizer (HPL), and a recommended inorganic rate (I). Poultry litter and inorganic fertilizer application rates are found in Table 1.

Harvest soil samples were analyzed for water pH (1:1 water extraction), orthophosphate by the Lachat QuickChem 8000, and all other nutrients by Mehlich-I extraction and measured on the ICP.

RESULTS

No statistical differences were observed to exist between tillage and nutrient content over this three year period ($p<=0.10$). Based on this, soil nutrient content was analyzed based on fertility treatment for the rest of this paper.

Soil water pH was found to be higher in the poultry litter treatments (NPL and HPL) than the I treatment (Table 2). Soil P availability (Table 3) was highest in the NPL soils, which was greater than the I soils ($p<=0.10$). Soil P availability was not different between the HPL and the NPL or I treatments ($p<=0.10$). Soil K availability (Table 3) was higher in the NPL soils than the other two treatments ($p<=0.05$). The HPL and I treatments were statistically similar to one another ($p<=0.05$). Available Zn (Table 4) was highest in the NPL soils which was significantly higher than the I treatment ($p<=0.10$). There were no differences between the HPL and the NPL or I soils ($p<=0.10$). Orthophosphate content (Table 5) was higher in the NPL soils than the I soils ($p<0.10$). The HPL soils were not different from either the NPL or I soils ($p<0.10$).

DISCUSSION

Many researchers have observed that poultry litter application can significantly raise soil water pH. Kingery et al. (1994) found that poultry litter application can result in an increase of up to 0.5 units. Nutrient accumulations are often found in soils that have received poultry litter application. In this study, P, K and Zn were found to increase with poultry litter application. In

a study by Sistani et al. (2004), available soil P was found to increase by 8 fold under high poultry litter application rates. Wood et al. (1996) saw an increase in available K and heavy metals with broiler litter application. Orthophosphate content is used to symbolize water soluble P, which was found to be higher in the litter soils than the non-litter treatment. If soluble P is present and not uptaken by the plant, then the concern focuses on water quality degradation from those treatments.

CONCLUSIONS

If poultry litter is applied at a rate that meets N requirements for the crop, accumulations of available P, K, Zn and orthophosphate will likely occur with time. Accumulations of nutrients in the soil is similar when using solely inorganic fertilizer (I) or ½ poultry litter + ½ inorganic fertilizer (HPL). According to our results, if a producer is going to use poultry litter as a fertilizer source, it is best to use ½ as much poultry litter as required and supplement the other nutrients from inorganic fertilizers.

ACKNOWLEDGEMENTS

UDSDA-ARS at Mississippi State, MS and Bowling Green, KY
Byron Sleugh and several WKU graduate and undergraduate student workers.

REFERENCES

Edwards, D.R. and T.C. Daniel. 1993. Effects of poultry litter application rate and rainfall intensity on quality of runoff from fescuegrass plots. J. Environ. Qual. 22: 361-365.

Franzluebbers, A.J., J.A. Stuedemann, and S.R. Wilkinson. 2002. Bermudagrass management in the southern piedmont USA. II. Soil phosphorus. Soil Sci. Soc. Am. J. 66: 291-298.

Han, F.X., W.L. Kingery, H.M. Selim, and P.D, Gerard. 2000. Accumulations of heavy metals in long-term poultry waste-amended soil. Soil Sci. 165: 260-268.

Kentucky Agricultural Statistical Service. 2003. Table 27. Poultry-Inventory and Number Sold: 2002 and 1997 [Online]. Available at http://www.nass.usda.gov/census/census02/volume1/ky/st21_1_02 7_029.pdf (verified 27 Oct. 2004).

Kingery, W.L. C.W. Wood, D.P. Delaney, J.C. Williams, and G.L. Mullins. 1994. Impact of long-term application of broiler litter on environmentally related soil properties. J. Environ. Qual. 23: 139-147.

Lander, C.H., D. Moffitti, and K. Alt. 1998. Nutrients available from livestock manure relative to crop growth requirements. Resource Assessment and Strategic Planning Working Paper 98-1 [Online]. Available athttp://www.nhq.nrcs.usda.gov/land/pubs/nlweb.html (verified 4 May 2000).

Sauer, T.J., T.C. Daniel, D.J. Nicols, C.P. West, P.A. Moore, Jr., and G.L. Wheeler. 2000. Runoff water quality from poultry litter-treated pasture and forest sites. J. Environ. Qual. 29: 515-521.

Sharpley, A.N., S.J. Smith, and W.R. Bain. 1993. Nitrogen and phosphorus fate from long-term poultry litter application to Oklahoma soils. Soil Sci. Soc. Am J. 57: 1131-1137.

Sistani, K.R., D.E. Rowe, J.Johson, and H. Tewolde. 2004. Supplemental nitrogen effect on broiler-litter-fertilized cotton. Agron. J. 96: 806-811.

Wood, B.H., C.W. Wood, K.H. Yoo, K.S. Yoon, and D.P. Delaney. 1996. Nutrient accumulation and nitrate leaching under broiler litter amended corn fields. Commun. Soil Sci. Plant Anal. 27: 2875-2894.

Table 1. Nutrient addition to soil by treatment.

Treatment	May 16, 2001	May 23, 2002	May 22, 2003	Material	Application Unit
NPL	11	18	20	Litter	Mg ha^{-1}
HPL	5.5	9.2	10	Litter	Mg ha^{-1}
	100	101	109	Inorganic N	Kg ha^{-1}
	45	24	34	Inorganic P_2O_5	Kg ha^{-1}
	45	38	31	Inorganic K_2O	Kg ha^{-1}
I	201	202	218	Inorganic N	Kg ha^{-1}
	90	47	68	Inorganic P_2O_5	Kg ha^{-1}
	90	76	62	Inorganic K_2O	Kg ha^{-1}

Table 2. Soil water pH values by treatment.

Treatment	Average pH value
NPL	6.4 a
HPL	6.42 a
I	6.12 b

Indicates statistical significance at the p<=0.05 level.

Table 3. Soil P and K availability by treatment.

Treatment	Average P content	Average K content
	----------Kg ha^{-1}----------	
NPL	254 a*	590 a**
HPL	152 ab	444 b
I	120 b	389 b

* Indicates statistical significance at the p<=0.10 level.
** Indicates statistical significance at the p<=0.05 level.

Table 4. Soil Zn availability by treatment.

Treatment	Average Zn content (Kg ha^{-1})
NPL	6.8 a
HPL	4.5 ab
I	3.5 b

Indicates statistical significance at the p<=0.10 level.

Table 5. Soil orthophosphate availability by treatment.

Treatment	Average ortho-PO_4 content (mg kg^{-1})
NPL	509 a
HPL	247 ab
I	151 b

Indicates statistical significance at the p<=0.10 level.