

DETERMINING THE EFFECT OF POULTRY LITTER AS A SOIL AMENDMENT FOR COTTON PRODUCTION ON HIGHLY DEGRADED LOESS SOILS OF NORTHEAST LOUISIANA**J. Lofton****LSU AgCenter****Winnsboro, Louisiana****J. Hendrix****LSU AgCenter****St. Joseph, Louisiana****J.C. Stevens****LSU AgCenter****Alexandria, Louisiana****B.S. Tubana****LSU AgCenter****Baton Rouge, Louisiana****T. Udeigwe****Texas Tech University****Lubbock, TX****J. Stapp****T. Talbot****LSU AgCenter****Winnsboro, Louisiana****Abstract**

Cotton has been the main agronomic crop in northeast Louisiana for many years. However, this mono-crop system has led to the decline of many soil properties. The application of organic amendments, such as poultry litter, has the potential to alleviate these problems, especially when paired with other best management practices. However, little information is available on these highly degraded soils. Therefore, a field trial was conducted to evaluate the effect of poultry litter applications paired with other best management practices, such as tillage and cover crops. Trials were conducted from 2008 through 2011 in Winnsboro, Louisiana. Poultry litter was applied at the rate of 0, 3.3, and 6.7 Mg ha⁻¹. Litter applications were evaluated over both conservation and conventional tillage operations as well as with and without a winter cover crop. Additionally, to simulate traditional production practices, an inorganic fertilizer treatment was included. Early season first flush run-off was collected following rainfall events. Soil samples were collected and total nutrient analyses was conducted. Cotton lint yields of the poultry litter treatments yielded significantly ($P < 0.05$) higher than those that received inorganic fertilizers. A significant build-up of Mehlich-3 extractable soil test P levels was found when poultry litter was incorporated compared to surface applied. However, surface poultry litter application resulted in a significant increase in first flush run-off P levels compared to incorporated litter. Poultry litter can be used as a soil amendment in northeast Louisiana; however, proper management needs to be emphasized to minimize environmental impact.

Introduction

Cotton has historically and will continue to be one of the most important row crops grown in Louisiana. However, decades of mono-crop cotton production paired with continuous intensive tillage operations has led to a steady decline in both soil nutrients and organic matter. This is illustrated by the upland loess soils of the Macon Ridge. Selim et al. (1983) described these soils as highly degraded with low inherent nutrient content and often containing low soil organic matter (SOM), with many fields having <1%. These highly degraded conditions have the potential to decrease the agronomic productivity on these soils. However, the application of organic amendments has the potential to alleviate many of these problems. Poultry litter (PL) is one of the most promising organic amendment sources for northern Louisiana due to its relative availability in the region as well as its high nutrient content, compared to other organic amendments (Edwards and Daniel, 1992).

Poultry litter has been documented as an effective alternate fertilizer source for agricultural production systems (Reddy et al., 2007; Tewolde et al., 2010a), especially on marginal production land (Hornick and Parr, 1987; Diacono and Montemurro, 2010). Tewolde et al., (2010a) reported that cotton lint yields increased when PL was used as an alternate fertilizer compared to inorganic fertilizers. They further suggested that this lint yield increase

was a result of more favorable soil pH and increased K, Mn, and B. Diacono and Montemurro (2010) reported similar results when on highly degraded soil. They documented a 250% increase in crop yield when comparing organic amendments to inorganic fertilizer additions. While these results indicate a promising use of PL as an organic amendment for cotton production, little research is available on the proper management of PL when paired with other best management practices, such as conservation tillage and cover crops. Additionally, while there has been increased knowledge on the environmental effects of PL application, still very little is known on how PL applications affect soil nutrient build-up and nutrient run-off. Therefore, the objectives of this study were to: 1) Evaluate the effects of PL applications on various cotton production systems on highly degraded loess soils, and 2) Determine the soils nutrient build-up and nutrient run-off through the application of PL paired with other best management practices.

Materials and Methods

Field trials were established at the LSU-AgCenter Macon Ridge Research Station near Winnsboro, Louisiana from 2008 to 2011 on a Gigger silt loam (Fine-silty, mixed, active, thermic Typic Fragiudalfs). These upland soils had <1% organic matter and possess a shallow impenetrable fragipan with an underlying moderately to very acidic sub-soil. Treatments consisted of three fertilization schemes, conventional and conservation tillage, and with or without a winter wheat cover crop. The three fertilization schemes evaluated were recommended N rate (PL-N), recommended P rate plus supplemental inorganic N (PL-P+N), and inorganic fertilizer with no poultry litter applications (NPL). The composition of the PL is presented in Table 1. The PL nutrient availability for year of application was assumed at 50% for N, 80% for P, and 100% for K. Treatments were arranged in a randomized complete block design with four replications.

Table 1. Poultry litter analysis for 2009 to 2011

Nutrient		Year		
		2009	2010	2011
Boron	mg kg⁻¹	114	89	NA^a
Copper	mg kg⁻¹	550	447	NA
Manganese	mg kg⁻¹	870	771	NA
Zinc	mg kg⁻¹	1051	803	NA
Aluminum	%	0.32	0.25	NA
Calcium	%	0.97	1.03	NA
Iron	%	0.75	1.04	NA
Potassium	%	5.11	3.3	2.56
Magnesium	%	10.4	0.84	NA
Sodium	%	0.27	0.16	0.15
Phosphorus	%	2.35	2.96	1.89
Sulfur	%	2.49	1.39	0.65
Nitrogen	%	2.17	3.3	2.3
Moisture	%	22	27	24

^aNutrient analysis was not conducted for the give nutrient on the given year

Plots were established in 2008; the field was disked and plots were bedded into four 102-cm wide beds and were 30.5 m in length. For the conservation tillage treatments, this was the only major tillage events, with the exception of bed reshaping in fall of 2010. Winter cover crop was planted in late fall annually with a Marliss grain drill (Model No. 14, Marliss Industries, Inc. Jonesboro, AR), with initial cover establishment in November 2008. Those plots which winter wheat was not planted, fields laid fallow and natural winter vegetation was allowed to grow. Early spring termination of the winter wheat cover crop as well as green winter vegetation, especially in the fallow

plots, was accomplished through the use of dicamba and glyphosate. Following cover crop and weed eradication, conventional tillage treatment beds were disked flat. Following initial tillage, fertilizer applications were made for both conservation and conventional tillage plots. The PL treatments were applied with a small-plot spreader equipped with a controlled applications system and was calibrated prior to applications. Inorganic fertilizers were applied as liquid urea ammonium nitrate with thiosulfate (30-0-0-2) knifed into the beds, triple superphosphate (0-45-0), muriate of potash (0-0-60), and zinc sulfate (36% Zn). Following fertilizer applications, conventional tillage treatments were bedded to fully incorporate both organic and inorganic fertilizers.

Plots were planted immediately following the application of treatments with DP 0912B2RF for all years. After planting, in-field water samplers were established at the end of each plot. Water samplers were hand-built and consisted of a 500mL triple rinsed bottle with a 0.3 m pvc piped attached to funnel water into the sampler. Water samples were collected from precipitation events and any early season irrigation events needed. Samplers were removed prior to lay-by operations and were not returned to the field until the following year. Plots were harvested, weighed, and hand-ginned to determine seedcotton yield and percent turnout, these values were used to determine final lint yields for each plot. Following harvest, soil samples (0-15 cm) were collected from each plot, air dried, and ground to pass a 2-mm sieve. Samples were then extracted with Mehlich-III solution and analyzed for plant available nutrients using ICP. Statistical analysis was conducted using Proc Mixed and contrast analysis in SAS.

Results and Discussion

Effect of year and interaction effects

Overall, cotton lint yields were found to be significantly affected by year ($P < 0.01$). As a result, analysis was carried out separately for each year. Additionally, no significant interaction was found between cover crop, tillage, or fertilizer scheme. This indicates that the application of fertilizer was not significantly affected by the cotton management. As a result, data for cotton lint yield, plant available soil nutrients, and run-off water was analyzed as separate main effects.

Cotton lint yield

The main treatment effect on cotton lint yields have been reported in Table 2. Cover crops and tillage main effects did not demonstrate a consistent influence on lint yields; however, conservation tillage systems yielded significantly higher than conventional tillage systems in 2011. Nyakatawa et al. (2000) reported that cotton lint yields were significantly higher in no-tillage systems compared to conventional or mulch tillage systems. They stated that a major contributing factor for this is the higher soil moisture during emergence and seedling growth for no-till compared to other systems. The results of this study showed a similar trend, with 2011 having drier early season conditions compared to both 2009 and 2010; therefore, the benefit of conservation tillage systems were more evident. Conversely, fertilizer scheme significantly affected lint yields (Table 2).

Table 2. Contrast analysis on the main treatments effects influence on cotton lint yield from 2009 to 2011 on highly degraded soils.

Contrasts	2009	2010	2011
Poultry litter vs. inorganic fertilizer	***	***	***
P-demand vs. N-demand	NS	NS	NS
cover crop vs. native fallow	NS	NS	NS
conventional tillage vs conservation tillage	NS	NS	***

*, **, *** represent $P < 0.05$, 0.01, and 0.001, respectfully

NS represents non-significant results

Across all years, plots which received PL treatments achieved 14% to 38% higher yields than plot which solely received inorganic fertilizers (Figure 1). Furthermore, applying higher PL to meet N recommendation did not increase lint yields compared to the lower P recommendations with supplemental inorganic N (Table 2). Several studies have documented this increase in lint yields with PL application compared to inorganic fertilizers (Reddy et al., 2004; Reddy et al., 2007; Tewolde et al., 2010). Additionally, Reddy et al. (2004) showed similar yield increases for PL treatments compared to those treated with ammonium nitrate. However, they found this yield

increases when PL was applied at double (202 kg N ha^{-1} PL compared to 101 kg N ha^{-1} ammonium nitrate). For this study, since N, P, K, and S were applied at similar rates for the PL and NPL treatments; the increased yield achieved from the PL applied plots was potentially due to more favorable growing and higher plant availability of these nutrients compared to NPL applied plots. Tewolde et al. (2010 and 2011) reported similar findings indicating high Mn, K, and B nutrient uptake and more favorable pH of PL applied treatments increased lint yields compared to inorganic treatments.

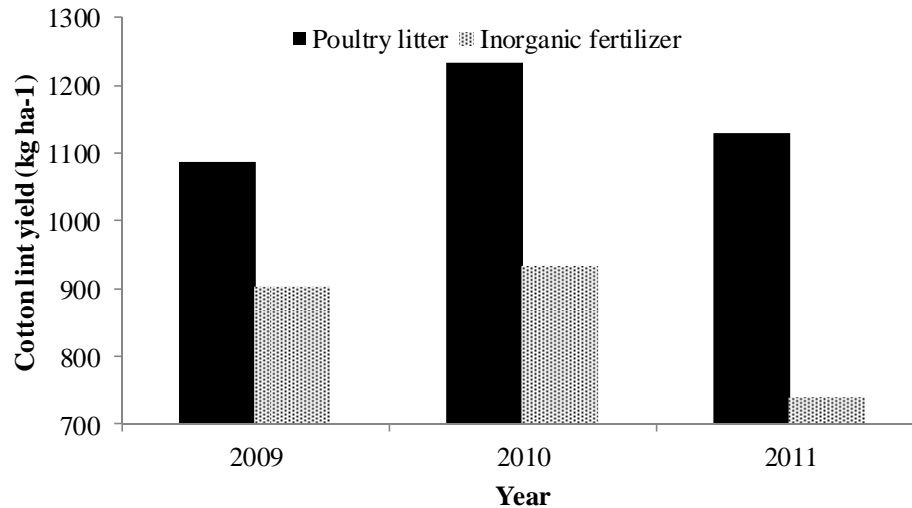


Figure 1. Cotton lint yield response to poultry litter and inorganic fertilizer additions from 2009 to 2011.

Plant available soil nutrients

Potentially the most detrimental effects of PL applications are the build-up of soil nutrients and the run-off of nutrients from production fields (Pote et al., 1996; Shepherd and Withers, 1999; He et al., 2009). Results from the contrast analysis for main effects influence on soil test P (STP) are presented in Table 3. Both fertilization scheme and PL application rate were found to have a significant effect on STP; however, there was no consistent significant effect of fertilization scheme, cover crops, or tillage on any other soil nutrients (data not shown). Higher STP values were found for the PL applied treatments compared to NPL treatments. Additionally, applying PL based on N demand significantly increased STP compared to the application based on P recommendations. As a result of the higher N:P ratio for PL, applying higher rates to meet the N demand have typically been shown to drastically increase STP. Shepherd and Withers (1999) reported not only similar increases in STP as a result of PL application, but also found an increased P content deeper in the profile with PL additions compared to inorganic fertilizers. To alleviate this build-up of P in these soil systems, they recommended implementing a management approach once every other or every third year.

Table 3. Contrast analysis on the main treatment effects influence on soil test P levels from 2009 to 2011.

Contrast	2009	2010	2011
Poultry litter vs. inorganic fertilizer	NS	***	***
1.5 ton vs. 3 ton ^a	NS	*	*
cover crop vs. fallow	NS	NS	NS
conventional tillage vs conservation tillage	NS	NS	NS

*, **, *** represent $P < 0.05$, 0.01 , and 0.001 respectively

NS represents non-significant results

Neither cover crop nor tillage showed a significant influence on the build-up of STP; however, there was a numerical increase in STP values for conservation tillage systems compared to conventional tillage systems. This

trend demonstrated that the incorporation of PL led to increase STP values compared to surface application without incorporation without significantly increasing yields.

Run-off samples

As a result of inconsistent rainfall events and localized showers no consistent run-off events could be collected for statistical analysis. However, observations on the data are consistent with previous findings and therefore will be discussed briefly. The application of PL increased P concentration in run-off samples compared to NPL treatments (Figure 2); however, tillage appeared more influential when averaged across fertilization scheme, especially for 2009 (Figure 3).

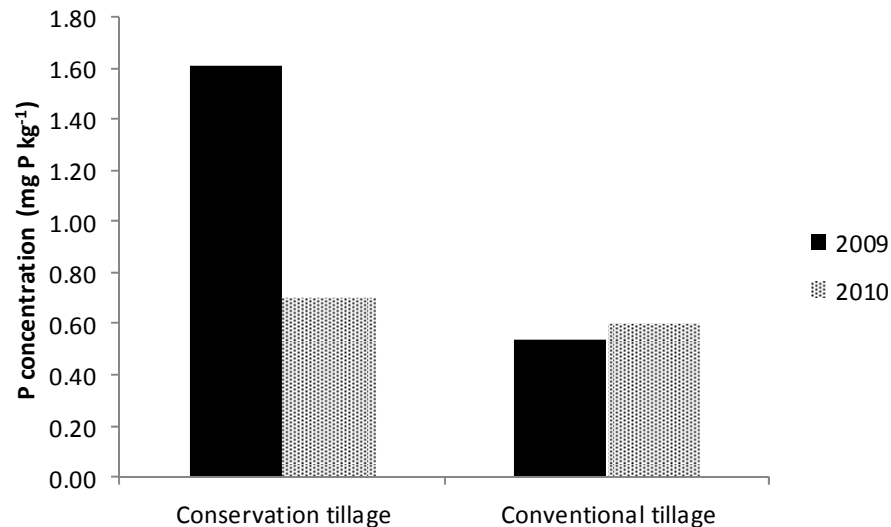


Figure 2. Effect of tillage system on run-off phosphate concentrations average across fertilization scheme for 2009 and 2010

Higher phosphate concentrations in the run-off samples were found under conservation tillage systems compared to conventional tillage. One potential explanation for this observation is the lack of incorporation of these soil amendments has increased nutrient concentrations in the upper soil profile. Sharply (2003) reported similar findings, indicating that when soils were applied with manure, plowing decreased STP values of the 0-5 cm samples compared to non-plowed soils. Furthermore, Sharply (2003) showed decreased overland P flow through plowing activities. He theorized that the plowing increased mixing of higher P soils (surface) with lower P soils (subsoil) which resulted in lower accumulation in surface soils as well as decreased P run-off.

Summary

According to the results of this study, cotton lint yield, plant available soil nutrients, and run-off nutrient content were influenced by not only PL applications but also tillage systems and cover crops. The application of PL had a positive effect on cotton lint yields in all experimental years. However, applying PL to meet the N demand on the cotton crop did not significantly increase cotton lint yields compared to applying based on P demand and supplementing with inorganic N fertilizers. Additionally, the application of PL to the production system increased both soil P accumulation as well as increase run-off P concentrations. This effect was exacerbated with higher applications of PL, which met the N demands but typically over-applied P. In addition, tillage practices were found to be influential to both nutrient accumulation and run-off. While not significant, when PL was incorporated through conventional tillage practices, soil build-up occurred; however, conservation tillage resulted in increased P values in run-off samples.

While the application of PL can be utilized to increase cotton lint yields, especially in highly degraded soils, proper management of the nutrient is necessary to ensure minimal environmental effect. While the long-term sustainability of yearly PL applications is low, Shepherd and Withers (1999) proposed the application of PL once every other or

every third years. This application frequency would potentially allow for the cropping system to benefit from an organic amendment (optimum pH, secondary macro- and micronutrients, and potential stimulation of soil microbial communities) as well as decrease the risk of increased nutrient build-up and run-off. However, very little research is currently available on the benefits and sustainability of this and other optimum production practices. Therefore, future research must address proper management of PL additions to cotton production systems to allow for the long-term use of this beneficial material.

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