Effects of Poultry Litter Ash and Raw Litter on Rice in an Eastern Arkansas Rice, Wheat, and Soybean Rotation

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RESEARCH PROBLEM

Land applications of abundant amounts of poultry litter in northwest Arkansas (NWA) have caused excessive soil phosphorous (P) levels for many soils in sensitive watersheds. Meanwhile, rice (*Oryza sativa*), soybean (*Glycine max*), and wheat (*Triticum aestivum*) producers in eastern Arkansas are adding inorganic P fertilizers to maintain or raise soil-test P levels. Currently, it is not economically profitable to transport raw chicken litter from NWA, where poultry litter is produced, to eastern Arkansas, the desired site for land applications. However, with new legislation, chicken litter may soon be mandated for export out of NWA and alum [($Al_2(SO_4)_3$] may be more commonly added to the litter to tie up the P and reduce the environmental risk when land applied. How will P in raw poultry litter with alum (PLWA) and without alum (PLWOA) and poultry litter ash (PLAsh, a byproduct from poultry litter incineration) react compared to inorganic triple superphosphate (TSP) fertilizer when applied to soils used for row-crop production in eastern Arkansas?

BACKGROUND INFORMATION

Poultry, in Arkansas, produce about 1.2 million tons of litter annually (Sims and Wolf, 1994). Due to over-application of litter in NWA, excessive soil-P levels in sensitive watersheds have been detected. Evidence linking current litter application procedures with pollution has increased interest in conservation methods that would limit applications in this region. An anticipated outcome of the Oklahoma and Arkansas controversy is that producers will soon be required to have a nutrient management plan to help curb over-application of litter, along with an agreement to ship 80,000 tons of litter out of the region (H.L. Goodwin, personal communication, 2002). Another benefit may arise from the development of a power generation facility from Fibrowatt, whose consolidated ash may also be a beneficial soil amendment with value as a fertilizer (Codling et al., 2002; Fibrowatt, 2004).

The objective of this research was to assess the economic validity and soil fertility concerns of using PLWA, PLWOA, and PLAsh as P fertilizer sources in comparison to TSP for rice, wheat, and soybean crop rotation systems.

PROCEDURES

Research plots were established in spring 2003 at the Pine Tree Experiment Station (PTES) in Colt, Ark., on a Calhoun silt loam (pH >6.5, Fine-silty, mixed, active, thermic Typic Glossaqualfs) and at the Rice Research and Extension Center (RREC) in Stuttgart, Ark., on a Dewitt silt loam (pH <6.5, Fine, smectitic, thermic Typic Albaqualfs). At each site, composite soil samples were taken from the 0- to 4-in. depth before treatments were applied and analyzed for pH and Mehlich-3 extractable P, K, Ca, Mg, Cu, Zn, Mn, Fe, Ni, Cd, Na, Al, As, and Pb (data not yet available).

Each experiment was conventionally tilled and drill seeded with ‘Wells’ rice. Each plot was 10-ft wide and 25-ft long with a 24-in. border separating adjacent plots. In general, University of Arkansas rice production recommendations for N, K, and Zn fertilization; irrigation; and pest control were followed (Slaton, 2001). At the 5-leaf stage, 140 lb N/acre as urea were broadcast to a dry soil surface and followed by establishing a 4-in. deep flood, which was maintained until draining about 10 days before harvest.

Each experiment was a randomized complete block with a 4 × 5 factorial treatment arrangement and four replications. Phosphorus sources were PLWA, PLWOA, PLAsh, and TSP with application rates of 0, 30, 60, 90, and 120 lb P_2O_5/acre. Selected chemical properties of the three litter sources are listed in Table 1. Total dry-matter accumulation was determined 14 and 35 days after flooding (DAF) by harvesting the aboveground plant tissues from 3-ft sections in the first or second inside row from each plot. Plant samples were dried at 140°F to a constant weight, weighed, ground, and digested to determine elemental concentrations. Rice grain yield and harvest moisture were determined at maturity by harvesting the middle 5-ft of each plot with a small-plot combine. Rice grain yields were adjusted to a uniform moisture content of 12% for statistical analysis.

General linear model (GLM) procedures were used to test for significance (SAS Institute, 2001). Significance levels of $p<0.10$ were chosen *a priori*. Means were separated using Fisher's protected least significant differences (LSD). Only rice yield, rice dry matter, and P uptake 14 and 35 DAF from 2003 are discussed in this manuscript.

RESULTS AND DISCUSSION

At the PTES, rice dry matter and P uptake 14 DAF were significantly affected by P source (Table 2). Poultry litter with alum and TSP provided superior rice biomass production compared to PLAsh. Likewise, plant uptake of P was greater from TSP as compared with PLAsh. Plant-available P appeared to be enhanced by the combination of raw litter and inorganic fertilizer sources on soil with pH >6.5.

The only significant effect at the RREC was P source with rice yields (Table 2). Poultry litter without alum, PLAsh, and TSP all produced greater yields than PLWA. Although not significant, plant uptake of P tended to decrease when soil was amended with PLWA in soils having pH <6.5.

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Table 1. Selected chemical properties of poultry litter with alum (PLWA), poultry litter without alum (PLWOA), poultry litter ash (PLAsh), and triple super phosphate fertilizer (TSP).

Source	Selected chemical properties										
	pH	N[z]	P[z]	K[z]	Ca[z]	C[z]	N	P_2O_5	K_2O	Ca	C[z]
		(% dry basis)					(lb/ton "as-is" basis)				
PLWA	6.3	5.17	1.25	2.90	1.82	35.24	80.3	44.5	54.5	28.3	547.8
PLWOA	8.5	4.23	3.39	3.32	2.49	36.22	60.9	55.9	57.9	35.8	521.6
PLAsh	N/A[y]	N/A	6.94	N/A	N/A	N/A	N/A	317.4	N/A	N/A	N/A
TSP	2.7	0.00	20.10	0.00	14.00	0.00	0.0	920.0	0.0	280.0	0.0

[z] Total amount of element found in source.
[y] Data analysis not received by publication deadline.

Table 2. Effect of poultry litter with alum (PLWA), poultry litter without alum (PLWOA), poultry litter ash (PLAsh), and triple superphosphate fertilizer (TSP) on rice dry-matter production and phosphorous (P) uptake 14 days after flood (DAF) at the Pine Tree Branch Station (PTES) in Colt, Ark., and rice yield at the Rice Research and Extension Center (RREC) in Stuttgart, Ark.

Source	PTES		RREC
	Rice dry matter[z]	P uptake[z]	Rice yield
	(lb/acre)		(bu/acre)
PLWA	1727 a	3.8 ab	184 c
PLWOA	1584 ab	3.7 ab	200 a
PLAsh	1446 b	3.3 b	192 b
TSP	1706 a	4.1 a	200 a
$LSD_{0.10}$	228	0.6	2

[z] Samples taken 14 DAF.