Inorganic Nitrogen Fertilizer and Pelleted Poultry Litter Increase Wheat Yield in Arkansas

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BACKGROUND INFORMATION AND RESEARCH PROBLEM

Balanced nitrogen (N) nutrition is essential for the production of high-yielding and quality wheat (*Trticum aestivum* L.). Many growers produce winter wheat following grain sorghum (*Sorghum bicolor* L) in rotation. Grain sorghum is a high-residue crop and information on wheat response to N fertilization in a wheat-sorghum rotation is useful for developing and refining our current wheat N-fertilization recommendations. The use of poultry litter as a fertilizer in the Mississippi Delta Region of Arkansas (MDRA) should be addressed to develop use guidelines for growers. To facilitate the transfer of nutrients from nutrient-rich poultry production areas, poultry litter is being pelletized as a means of reducing transportation cost. Pelleted poultry litter (PPL) contains N, P, K, and small quantities of micronutrients. Pelleted litter is currently marketed by some fertilizer distributors in the MDRA as a fertilizer. However, there is little information on crop and soil response to PPL in crop production systems of the MDRA. The objectives of the experiment were to evaluate the effect of N source and application rate on wheat grain yield and to evaluate the effect of poultry litter on soil chemical properties.

PROCEDURES

A replicated field experiment was conducted at the University of Arkansas Cotton Branch Experiment Station (CBES) in Marianna, Ark., on a Calloway silt loam during the 2003 growing season. 'Sabbe' wheat was drill seeded (6-inch row spacing) at 120 lb/acre on 25 October 2003. Nitrogen fertilizer was applied as urea (Urea) in late winter or as pelleted litter either preplant-incorporated in the fall (PPLF) before seeding or surface-applied in late winter (PLLW) at five N rates. Urea was applied at rates of 40, 80, 120, 160, and 240 lb N/acre on 2 March 2004. Pelleted litter (4.05% total N) was applied at rates of 1000, 2000, 3000, 4000, and 6000 lb/acre, which corresponds to total-N rates of 40, 81, 122, 162, and 243 lb N/acre. Nitrogen rates for all sources will be referred to as 40, 80, 120, 160, and 240 lb N/acre. An unfertilized control (0 lb N/acre) was also included. Each plot was 30-ft long and 5-ft wide and contained 10 rows of wheat. All plots were fertilized with triple superphosphate and muriate of potash to supply 40 and 30 lb/acre of K_2O and P_2O_5, respectively, to ensure that yield was not limited by K or P deficiency. All preplant fertilizers were broadcast and then mechanically incorporated. Standard cultural practices recommended by the University of Arkansas Cooperative Extension Service were followed.

The experiment was a randomized complete block with a 3 (N source/time) × 5 (N rate) factorial treatment structure with five replications. The entire plot was harvested with a small plot combine. Grain moisture values were adjusted to a uniform moisture content of 13% for statistical analysis.

Composite soil samples were collected from the 0- to 6-inch depth of the control and the low and high N rate treatments of each source in the fall before treatments were applied and from all treatments in the first four replications after wheat harvest (6 June 2004). Soil samples were oven dried, crushed, extracted with Mehlich-3 solution (1:10 ratio), and the concentration of elements in the extract was measured by Inductively Coupled Plasma Atomic Emission Spectroscopy. Soil nitrate was extracted with aluminum sulfate and measured with a specific-ion electrode. Soil pH was measured in a 1:2 (weight:volume) soil-water mixture.

Analysis of variance procedures were conducted for wheat yield and post-harvest soils data using the PROC GLM procedure in SAS (SAS Institute, Inc., Cary, N.C.). When appropriate, mean separations were performed using the Fisher's Protected Least Significant Difference method at a significance level of 0.1.

RESULTS AND DISCUSSION

Wheat grain yields were significantly affected by the source of N, averaged across N rates, and N rate, averaged across N sources (Table 1). Application of urea significantly increased wheat yields compared with pelleted litter, regardless of application time. Wheat yields receiving either fall- or late-winter-applied pelleted litter produced significantly greater wheat yields compared with the unfertilized control. Application of urea at 120 lb N/acre produced the maximum yield of 4621 lb/acre (77 bu/acre), but urea at rates >120 lb N/acre caused lodging and tended to decrease wheat yields. Data suggest that pelleted poultry litter applied at intermediate to high rates can provide some N to winter wheat when applied either in the fall or late winter, but will likely require supplemental inorganic N fertilizer to produce maximal yields.

Preplant soil samples showed that the mean pH was 6.1, estimated cation exchange capacity (ECEC) averaged 13 $cmol_c$/kg soil, soil organic matter (SOM) averaged 1.6%, and base saturation (BS) averaged 73%. Mehlich-3-extractable P and K were > 80 and 220 lb/acre, respectively, and considered sufficient for wheat production. Chemical analysis of soil samples collected after wheat harvest indicated that the N source, averaged across all N rates, significantly affected soil P, K, Cu, and Zn (Table 2). For all of these nutrients the pelleted poultry litter-treated soils had similar levels of P, K, and Zn as the unfertilized control, but were greater when compared to the inorganic N fertilizer. Because the unfertilized control Zn and P were similar to soil receiving litter, there may have been significant variability among plots before fertilizers were applied or soil-test nutrient concentrations may have been affected by whet yield. Soil Cu was the only extracted nutrient that poultry litter may have actually increased. Averaged across the N sources, the application of poultry litter significantly (P=0.1) increased Mehlich-3-extractable Cu presumably due to the effect of poultry litter applied at N rates > 120 lb/acre.

PRACTICAL APPLICATIONS

Pelleted poultry litter applied either in the fall or late winter significantly increased wheat grain yields compared with the unfertilized control. However, when compared with yields of wheat receiving 120 lb N/acre as urea (applied in late winter), pelleted poultry litter at rates up to 6000 lb/acre failed to produce maximal wheat yields. Therefore, yield data from this one study suggest that pelleted litter can supply only a portion of the N required by wheat to produce maximal grain yields. Supplemental N applied in late winter is needed to produce maximal wheat yields. Further studies are required to more accurately delineate the amount of plant-available nutrients provided by fall- or late-winter-applied pelleted litter to winter wheat in Arkansas and to monitor its influence on soil fertility as determined by soil-testing.

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Table 1. Influence of N source, averaged across N rates, and N rate, averaged across N sources, on wheat grain yields at the Cotton Branch Experiment Station in 2003-2004.

N source	Wheat yield	N rate	Wheat yield
	(lb grain/acre)	(lb N/acre)	(lb grain/acre)
None	2767	0	2767
Pelleted litter (Fall)	3525	40	3417
Pelleted litter (Late Winter)	3528	80	3634
Urea	4246	120	3646
		160	3973
		240	4195
P-value	0.0041		0.0716
LSD (0.10)	651		650

Table 2. The effect of inorganic-N (INF), pelleted poultry litter applied in the fall (PPLF), and pelleted poultry litter applied in the winter (PPLW), averaged across N rates, on selected soil chemical properties from soil samples (0- to 6-in depth) collected after wheat harvest at the Cotton Branch Station.

N source	Soil pH[z]	Soil OM[y]	Soil NO_3-N[x]	P[w]	K[w]	Ca[w]	Mg[w]	Cu[w]	Zn[w]
(lb/acre)		(%)	(lb/acre)						
None	6.3	1.8	4	144	363	2579	712	2.9	5.7
INF	6.3	1.8	5	126	334	2414	675	2.8	4.8
PPLF	6.3	1.8	4	146	384	2478	698	3.2	5.4
PPLW	6.3	1.9	4	148	423	2506	705	3.3	5.9
P-Value[v]	0.50	0.20	0.13	< 0.001	< 0.001	0.38	0.50	< 0.001	0.0002
LSD (0.10[v])	NS	NS	NS	12	40	NS	NS	0.2	0.6

[z] Soil pH was measured in a 1:2 (weight:volume) soil-water mixture.
[y] OM, soil organic matter determined by Weight Loss on Ignition.
[x] NO_3-N measured by ion-specific electrode.
[w] Mehlich-3-extractable soil nutrients (1:10 extraction ratio).
[v] Minimum Significant Difference as determined by LSD Test (NS, not significant at *P*=0.1).

Table 3. The effect of N rate, averaged across the N sources, on chemical properties of the soil samples collected after wheat harvest from the 0- to 6-in depth at the Cotton Branch Station.

N rate	Soil pH[z]	Soil OM[y]	Soil NO_3-N[x]	P[w]	K[w]	Ca[w]	Mg[w]	Mn[w]	Cu[w]	Zn[w]
(lb/acre)		(%)	(lb/acre)							
0	6.3	1.8	4	144	363	2579	712	223	2.9	5.7
40	6.4	1.8	4	132	394	2443	693	218	2.9	5.3
80	6.2	1.9	5	138	391	2500	715	223	3.1	5.3
120	6.3	1.8	5	136	368	2492	687	224	3.0	5.3
160	6.4	1.8	5	147	379	2407	673	231	3.1	5.7
240	6.2	1.9	5	146	369	2487	695	236	3.3	5.4
P-Value[v]	0.08	0.60	0.56	0.11	0.65	0.8	0.8	0.69	0.02	0.49
LSD0.10[v]	0.1	NS	NS	NS	NS	NS	NS	NS	0.3	NS

[z] Soil pH was measured in a 1:2 (weight:volume) soil-water mixture.
[y] OM, soil organic matter determined by Weight Loss on Ignition.
[x] NO_3-N measured by ion-specific electrode.
[w] Mehlich-3-extractable soil nutrients (1:10 extraction ratio).
[v] Minimum Significant Difference as determined by LSD Test (NS, not significant at *P*=0.1).