Soybean Growth and Yield Responses to Poultry Litter and Inorganic Fertilizer

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Introduction

Arkansas ranked ninth and second in soybean [*Glycine max* (Merr) L.] and broiler chicken production, respectively, in 2003. In western Arkansas, poultry litter can not be applied to many fields near poultry production facilities due to high soil-test P and needs to be transported out of watersheds designated as Nutrient Surplus Areas. Substantial price increases of inorganic P and K fertilizers have caused farmers to seek alternative P and K sources for row crop production in eastern Arkansas.

Published literature contains few conclusive reports concerning the availability of P and K in animal manures. Fertilizer recommendations are commonly based on trials with inorganic P and K sources. Knowledge of the P and K availability in animal manures or their equivalence to inorganic fertilizer sources is needed to provide growers with sound agronomic recommendations on soils that require P and K to ensure agronomic production is optimized.

The primary research objective was to compare soybean tissue P and K concentrations and seed yield when fertilized with equal rates of P and K applied as inorganic P (triple superphosphate) and K (muriate of potash) fertilizers or poultry litter.

Materials and Methods

✓ Experiments were established at 8 site-years from 2004 – 2006 on silt loam (6) and clayey (2, Tunica) soils in eastern Arkansas (Table 1).

✓ Pelleted poultry litter was applied to the soil surface before seeding and compared to equal rates of P as triple superphosphate and K as muriate of potash. Rates were based on litter P content and included ~15, 30, 45, 60, and 75 kg P/ha (30, 60, 90, 120, and 150 lbs P_2O_5/acre) plus an unfertilized control (0 kg P and K/ha). Inorganic K fertilizer rates were applied to match the total K content of each P-based litter rate.

✓ A single soybean (Maturity Group III, IV, or V) cultivar was seeded at each site.

✓ Recently mature trifoliate leaves (15) were collected from the middle of each plot at the R2 stage and analyzed for nutrient concentrations.

✓ Seed yield was measured at maturity.

✓ Composite soil samples (0-10-cm depth) were collected before treatment application and analyzed for soil pH and Mehlich-3 extractable nutrients.

✓ Treatments were arranged as a randomized complete block design with a 2 (PK source) × 5 (PK rate) factorial treatment structure and 4 or 5 replicates/site-year (Tunica, Calhoun, and Calloway soils) or as a RCB of litter rates (Dewitt and Henry sols) due to P and K application to the research areas.

✓ Analysis of variance was performed on each trial using Fisher's Protected Least Significant Difference method (SAS v9.1) at a significance level of 0.10.

Table 1. Selected mean soil (0-10 cm depth) properties, litter P and K content, and agronomic information for eight sites evaluating soybean response to pelleted litter and inorganic P and K fertilizer rate.

Soil Series - Year	Soil pH	Mehlich-3 P	Mehlich-3 K	Cultivar	Date Seeded	Litter P	Litter K
		mg/kg	mg/kg		Mo/Day	%	%
Tunica-04	6.7	54	281	Progeny 5250	6/8	1.38	2.55
Tunica-05	6.6	35	273	Asgrow 5501	6/6	1.55	2.57
Calloway-05	7.1	38	155	Armor 53K3	5/12	1.55	2.57
Calhoun-06	7.6	42	168	Armor 53K3	5/15	1.32	2.72
Dewitt-04*	5.6	15	123	Progeny 5250	5/26	1.38	2.55
Dewitt-05*	6.0	31	158	Asgrow 5501	5/24	1.55	2.57
Henry-04*	6.6	47	135	Asgrow 4403	5/7	1.38	2.55
Henry-05*	7.5	82	124	Pioneer 93M90	4/26	1.55	2.57

* Inorganic P and K fertilizer was applied to test sites before study was established and soil samples collected (inorganic fertilizer treatments were omitted from analysis).

Table 2. Soybean yield and trifoliate leaf (R2 stage) P and K concentrations as affected by P and K source, averaged across application rates, at four test sites.

PK Source	Site-year Tunica 2004	Tunica 2005	Calloway 2005	Calhoun 2006
	- - - - - Grain Yield (kg/ha) - - - - -			
Control	4099	4234	4973	3427
Litter	4099	3898	4906	3562
Inorganic Fert.	4166	4099	4771	3494
$LSD_{0.10}$	NS	NS	NS	NS
Nutrient	Mean trifoliate-leaf concentrations			
N, %	--	4.83	5.31	4.84
P, %	0.48	0.40	0.48	0.40
K, %	2.43	2.26	2.12	1.86
B, ppm	41	48	39	13

Leaf nutrient concentrations were not affected by nutrient rate, PK source, or their interaction.

Table 3. Soybean yield and trifoliate leaf (R2 stage) P and K concentrations as affected by P and K rate applied as litter, averaged across PK sources, at four sites.

PK rate	Site-year Dewitt 2004	Dewitt 2005	Henry 2004	Henry 2005
kg P/ha	- - - - - Grain Yield (kg/ha) - - - - -			
0	3763	4966	2917	4381
15	3716	5221	3414	4570
30	4254	4664	3199	4677
45	3683	4879	3286	4966
60	3830	4583	3763	5363
75	3636	4556	3750	5389
$LSD_{0.10}$	NS	NS	**343**	**544**
Nutrient	- - Trifoliate-leaf concentrations - -			
N, %	--	4.79	--	*
P, %	0.29	0.43	*	0.47
K, %	1.58	2.12	*	*
B, ppm	37	*	36	*

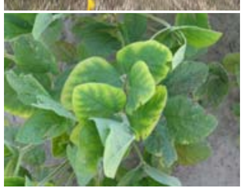

Table 4. Influence of litter rate on trifoliate leaf P, K, and B concentrations of soybean grown on a Henry silt loam in 2004 and 2005.

P rate as litter	%P 2004	%K 2004	%K 2005	B (mg/kg) 2005
kg P/ha	- - - Tissue Conc. (% or mg/kg) - - -			
0	0.39	1.54	1.65	22.4
15	0.42	1.68	1.61	22.2
30	0.44	1.70	1.78	25.8
45	0.42	1.68	1.77	28.2
60	0.48	1.81	1.84	30.4
75	0.45	1.80	1.82	31.1
$LSD_{0.10}$	0.04	0.15	0.14	3.7

Results

✓ All sites had soil-test K levels categorized as Medium (91-130 ppm) or Optimum (131-175 ppm) (Table 1).

✓ Soil-test P levels were categorized as Very Low (<16 ppm), Medium (26-35 ppm), Optimum (36-50 ppm) or Above Optimum (>50 ppm) for soybean (Table 1).

✓ P and K application rate and source had no influence on yield and trifoliate leaf nutrient concentrations at the R2 stage of soybean grown on the Tunica, Calloway, and Calhoun soils which had 'Optimum' soil-test P and K levels (Table 2).

✓ Trifoliate leaf N, P, K, and B concentrations were not affected by PK source or application rate for any study on the Tunica, Calloway, and Calhoun soils.

Results

✓ Soybean (MG-5 cultivars) grown on the Dewitt soil showed no positive response to poultry litter rate (Table 3). Data for inorganic P and K fertilizer was omitted from analysis for this series because P and K fertilizer had been applied to the test sites before establishment. However, statistical analysis showed no yield benefit from extra P and K fertilizer.

✓ Soybean (MG-3 & -4 cultivars) grown on the Henry soils responded positively to poultry litter rate (Table 3). Soybean receiving inorganic P and K fertilizer (data not shown) produced yields similar to the control.

✓ Tests on the Henry soil also had inorganic P and K applied to the test area before establishment suggesting the positive yield response to poultry litter may have been from N or another unidentified beneficial factor in the litter.

✓ We hypothesize that soybean with early planting dates and indeterminate cultivars (MG-3 or -4) grown on the Henry soil may have benefited from the N applied as poultry litter by stimulating early season growth when soil temperatures are typically low and soybean growth is relatively slow.

✓ For soybean grown in the Henry soil, trifoliate leaf P, K, and B concentrations were significantly affected by litter application rate in 2004 and 2005 (Table 4). Tissue P, K, and B concentrations tended to increase as litter rate increased.

Conclusion

✓ The inorganic P and K fertilizer equivalence of P and K in pelleted poultry litter could not be assessed from these studies, but data suggest poultry litter may enhance soybean yields in some field situations (e.g., early planting, no-till).

Additional Research

✓ Two additional experiments were established with MG-4 soybean on soils with 'Medium' soil-test K and 'Low' or 'Optimum' soil-test P levels in 2007 comparing fresh poultry litter and inorganic P and K fertilizers.

✓ Additional studies were established with inorganic N fertilizer to evaluate the potential for yield responses to N fertilization with April-planted MG-4 soybean cultivars.

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