SWINE MANURE APPLICATIONS FOR SOYBEAN PRODUCTION – ENVIRONMENTAL AND PATHOLOGICAL IMPLICATIONS

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Introduction

Soybeans are leguminous plant species capable of fixing nitrogen (N) from the atmosphere to support their growth and development. Despite the fact that soybeans can fix their own N, in a soil environment rich in inorganic N they will scavenge for available N decreasing the level of root nodulation (Schmidt et al., 2000; Hesterman and Isleib, 1991). Studies conducted to measure the impact of N fertilization of soybeans reveals that crop response to commercial N fertilizer does not result in increased crop production unless soil conditions inhibit rhizobium infection (low soil pH, cool, wet soils, etc.) (Reese Jr., and Buss, 1992; Schmidt et al., 2000; Osborne and Riedell, 2006). Because soybeans are unlikely to benefit from N fertilization most Land Grant Universities do not recommend application of N containing fertilizers to soybeans because it is not economical to do so unless extraneous soil conditions exist. Manure application for soybean production can provide needed phosphorus, potassium, and additional nutrients, but because of the environmental risks associated with excessive application of N state and federal agencies have considered encouraging producers not too apply manure on soybean production ground. This could place more pressure on swine operations to identify available land for recycling manure nutrients.

Previous work has shown that soybeans can take up soil inorganic nitrogen from both manure and commercial forms of nitrogen. The most extensive work was conducted in Minnesota, but this experiment relied on post-harvest soil profile nitrate analysis to determine residual nitrate to a depth of four feet (Schmidt et al., 2000). Ohio production fields are extensively tiled (drained) to an average depth of 30 to 36 inches, and thus a single post-harvest estimate of profile nitrate may be misleading. This is especially true if the growing season has been exceptionally wet.

Organic soil amendments can have positive impacts on soil borne pathogens and plant health (Hoitink and Boehm 1999, Lazarovits 2001). In soybeans, several researchers have conducted investigations into the effects of manure applications on crop health and found that results are dependent upon the timing and amount of organic amendment applied. For example, application of compost 3 to 6 months prior to soybean planting resulted in decreased *Phytophthora* damage and increased yield in moderately susceptible cultivars (Hoitink and Schmitthenner, 1988). Swine manure has also shown some suppressive ability on soybean cyst nematode egg hatch attributed to high salt content and high concentration of organic chemicals, though SCN egg counts were increased in the fall due to manure application (Reynolds et al., 1999). However, high rates of swine manure application have also been shown to aggravate other soilborne disease problems such as white mold (Schmidt et al 2001). Thus, it is important to systematically determine how timing and rate affect disease pressure so as to not negatively offset the nutrient benefits of such applications.

Objectives

The objective of this study was to evaluate the impact of manure application to soybean fields on soil nitrate accumulation and soybean crop productivity. Additionally, this work was conducted to determine the impact of manure application on soil-borne pathogens specifically soybean cyst nematode.

Materials and Methods

A single field experiment was established in the spring of 2007 at the OARDC Western Research Station near South Charleston, OH. Manure was applied at three N rates 60, 120, and 180 lb/acre assuming that one third of the organic fraction was considered plant available and the ammonium-N manure fraction was considered 75% plant available. Manure samples were collected from the pit during and after application and used to represent the average manure analysis (Table 1). Historical manure analysis was used to determine manure application rates (Table 1). Liquid swine manure was applied either as a surface treatment or subsurface injected using Dietrich shanks. All plots that received subsurface injected liquid swine manure were tilled, and the surface application treatments were either no-tilled or tilled. Tillage comprised of a single tandem offset disk pass and a single pass of a finishing tool. Liquid swine manure was applied to the soil surface treatments on April 10. Due to rainfall on April 11, the subsurface treatments were applied on April 18, and tillage was done on April 20. A randomized complete block experimental design was used with four replications. Each plot was 10 ft by 30 ft. Phosphorus and potassium were supplied at rates equivalent to the amount of P and K supplied by the manure application. Urea, triple-superphosphate, and potash were supplied to the commercial treatments. Manure analysis information is presented in Tables 1 and 2.

Soil samples were collected at three dates – June 1, June 28, and July 18, and tissue samples were collected on June 28 and July 18 (that correspond with soybean vegetative stage V4 and R1, respectively). Soil samples were collected to a depth of 24" on the first two sampling dates and to a depth of 12" on the third sampling date due to dry soil conditions. Soil ammonium-N analysis was done using the steam distillation method, and nitrate-N analysis was done using an ion selective electrode (ISE). Tissue N concentration was determined using dry combustion. Statistical analysis to determine differences between treatments was done using single degree of freedom contrasts in PROC GLM in SAS (SAS, 1998).

Results and Discussion

Soybean Biomass and Nitrogen Uptake

Soybean biomass, tissue N concentration, and N uptake measured at V4 were not significantly affected by fertilization (swine manure or commercial fertilizer) despite the low initial soil test values (Tables 3 and 4). At the R1 growth stage, interactions were noted for all measured parameters thus only simple effects will be discussed. Soybean biomass showed a linear response to N application rate for the commercial fertilizer treatments, but not the manure treatments regardless of application methodology or tillage (Table 5). This response was unlikely due to the actual N application, but more likely attributable to the P and K added. A linear response to N application was noted for soybean tissue N concentration in the injected manure treatments, but not the surface manure or commercial fertilizer treatments. Similar to soybean biomass measurements at the R1 growth stage, a linear increase in soybean N uptake was observed as N application rate increased for the commercial fertilizer treatments but not for the manure application treatments.

Soil Nitrate

Soil nitrate levels increased linearly at the 0-12" depth as N application rate increased across all application methodologies for the first soil sampling time (Table 6). A linear response to N application rate was only observed for soil nitrate levels at the 0-12" depth when manure was injected (Table 7). Soil nitrate levels in the 12-24" depth were not significantly different than the controls for the second sampling date. At the third sampling date, soil nitrate levels at the 0-12" depth showed a linear response to N application rate only when manure was injected below the soil surface (Table 8).

Soil nitrate levels generally increased at the 0-12" depth as N application rate increased when manure was subsurface injected especially at the highest N rate This implies that N application rates greater than expected crop removal may result in excess soil nitrate levels at least in the 0-12" depth. This finding is not surprising. The data does show that N can be applied to soybean with little risk if N application rates are below expected crop removal. In this case, N applications should probably not exceed 120 lb N/acre.

References

Hesterman, O.B., and T.G. Isleib. 1991. Response of first-year soybeans to row spacing, inoculation treatments, and nitrogen fertilization. J. Prod. Agric. 4:589-593.

Hoitink, H.A.J., and M.J. Boehm. 1999. Biocontrol within the context of soil microbial communities: a substrate-dependent phenomenon. Ann. Rev. Phytopathol. 37:427-446.

Hoitink, H.A.J., and A.F. Schmitthenner. 1988. Effects of composted municipal sludge on soilborne plant pathogens. Project Summary, United States Environmental Protection Agency, Water Engineering Research Laboratory, Cincinnati, OH.

Lazarovits, G. 2001. Management of soil-borne plant pathogens with organic soil amendments: a disease control strategy salvaged from the past. Can J. Plant Pathol. 23:1-7.

Osborne, S.L., and W. Riedell. 2006. Soybean growth response to low rates of nitrogen applied at planting in the northern Great Plains. J. Plant Nutr. (in print).

Reese, Jr., P.R., and G.R. Buss. 1992. Response of dryland soybeans to nitrogen in full-season and double crop soybeans. J. Prod. Agric. 5:528-531.

Reynolds, D.A., G.L. Tylka, and C.A. Martinson. 1999. Effect of swine manure on soybean cyst nematode. National Soybean Cyst Nematode Conference, January 7-8, Orlando, FL.

SAS Institute, Inc. 1998. SAS/STAT User's Guide, 6.03 Ed. SAS Institute, Inc., Cary, NC.

Schmidt, J.P., Schmitt, M.A., Randall, G.W., Lamb, J.A., Orf, J.H. and H.T. Gollany. 2000. Swine manure application to nodulating and nonnodulating soybean. Agron. J. 92: 987-992.

Schmidt, J.P., Lamb, J.A., Schmitt, M.A., Randall, G.W., Orf, J.H. and H.T. Gollany. 2001. Soybean varietal response to liquid swine manure application. Agron. J. 93:358-363.

Table 1. Initial manure test values, sampled winter 2005.

Moisture (%)	Total N	Ammonia-N	Organic-N	P_2O_5	K_2O
	--------------------	--------------------	lbs/1000 gal	--------------------	--------------------
95.9	42.1	29.9	12.2	21.3	25.1

Table 2. Manure analysis as applied.

Moisture (%)	Total N	Ammonia-N	Organic-N	P_2O_5	K_2O
	--------------------	--------------------	lbs/1000 gal	--------------------	--------------------
96.7	26.1	22.7	3.3	15.9	19.4

Table 3. Initial soil test information.

Soil pH[a]	Available P[b] (mg/kg)	Exchangeable K[c] (mg/kg)	Organic matter[d] (%)
5.9	17	87	2.5

a-1:1 soil:water; b-Bray-Kurtz P-1; c-ammonium acetate; d-loss on ignition

Table 4. Simple effects of manure and commercial fertilizer applied on soybean dry weight, tissue N concentration, and N uptake measured on June 28, 2007.

Application method	N source	N rate (lb/acre)	Dry weight (lb/acre)	Tissue N (%)	N uptake (lb/acre)
Surface (tilled)	None	0	2940	3.5	103
Surface (no-tilled)	None	0	4029	3.5	139
Injection (tilled)	None	0	2505	3.5	87
Injection (tilled)	Manure	60	3702	3.5	128
		120	3812	3.7	140
		180	4356	3.8	168
Surface (tilled)	Manure	60	3158	3.5	109
		120	3812	3.8	135
		180	3158	3.5	113
Surface (no-tilled)	Manure	60	3376	3.7	126
		120	3158	3.6	113
		180	3812	3.4	130
Surface (tilled)	Commercial	60	3703	3.4	125
		120	2614	3.6	91
		180	4356	3.8	167
Contrasts					
Fertilized versus controls			NS	NS	NS

***, **, * - significant at the 0.01, 0.05, 0.1 probability levels, respectively; NS – non-significant; NA-not applicable

Table 5. Simple effects of manure and commercial fertilizer applied on soybean dry weight, tissue N concentration, and N uptake measured on July 18, 2007.

Application method	N source	N rate (lb/acre)	Dry weight (lb/acre)	Tissue N (%)	N uptake (lb/acre)
Surface (tilled)	None	0	7296	4.3	313
Surface (no-tilled)	None	0	10890	3.9	421
Injection (tilled)	None	0	10237	4.0	411
Injection (tilled)	Manure	60	9909	4.1	411
		120	12033	4.4	528
		180	12142	4.7	565
Surface (tilled)	Manure	60	12197	4.3	530
		120	11652	4.3	505
		180	12632	4.5	564
Surface (no-tilled)	Manure	60	10237	4.1	420
		120	12088	4.3	522
		180	12088	4.5	539
Surface (tilled)	Commercial	60	11326	4.3	482
		120	16444	4.5	739
		180	16771	4.3	712
Contrasts					
Fertilized versus controls			***	***	***
Manure versus commercial X N rate linear			**	NS	*
N rate linear			NA	**	NA

***, **, * - significant at the 0.01, 0.05, 0.1 probability levels, respectively; NS – non-significant; NA-not applicable

Table 6. Effects of manure and commercial fertilizer applied on soil ammonium and nitrate concentrations at two depths (0-12" and 12-24") measured on June 1, 2007.

Application method	N source	N rate (lb/acre)	Nitrate-N concentration	
			0-12"	12-24"
			---------------mg/kg-------------	
Surface (tilled)	None	0	9.1	6.5
Surface (no-tilled)	None	0	10.9	6.3
Injection (tilled)	None	0	15.0	7.5
Injection (tilled)	Manure	60	13.1	8.3
		120	27.6	8.3
		180	22.8	8.0
Surface (tilled)	Manure	60	13.6	7.0
		120	20.1	7.7
		180	21.8	8.4
Surface (no-tilled)	Manure	60	16.1	7.1
		120	17.8	7.6
		180	23.0	10.4
Surface (tilled)	Commercial	60	16.0	7.1
		120	25.9	9.6
		180	29.1	9.2
Contrasts				
Fertilized versus controls			***	*
N rate linear			***	NS
Manure versus commercial X N rate linear			NS	NS

***, **, * - significant at the 0.01, 0.05, 0.1 probability levels, respectively; NS – non-significant; NA-not applicable

Table 7. Effects of manure and commercial fertilizer applied on soil ammonium and nitrate concentrations at two depths (0-12" and 12-24") measured on June 28, 2007.

Application method	N source	N rate (lb/acre)	Nitrate-N concentration	
			0-12"	12-24"
			--------------mg/kg--------------	
Surface (tilled)	None	0	10.6	6.4
Surface (no-tilled)	None	0	6.4	5.2
Injection (tilled)	None	0	7.4	6.4
Injection (tilled)	Manure	60	7.9	6.3
		120	9.6	6.6
		180	23.4	9.8
Surface (tilled)	Manure	60	8.9	5.6
		120	15.4	10.1
		180	14.1	7.9
Surface (no-tilled)	Manure	60	10.8	6.2
		120	15.1	7.4
		180	19.0	8.0
Surface (tilled)	Commercial	60	10.7	6.1
		120	14.1	6.7
		180	17.5	8.3
Contrasts				
Fertilized versus controls			***	NS
Manure injected versus surface (tilled) X N rate linear			**	NA

***, **, * - significant at the 0.01, 0.05, 0.1 probability levels, respectively; NS – non-significant; NA-not applicable

Table 8. Effect of manure and commercial fertilizer applied on soil ammonium and nitrate concentrations at one depth (0-12") measured on July 18, 2007.

Application method	N source	N rate (lb/acre)	Nitrate-N concentration (mg/kg)
Surface (tilled)	None	0	5.9
Surface (no-tilled)	None	0	5.7
Injection (tilled)	None	0	5.4
Injection (tilled)	Manure	60	7.6
		120	11.2
		180	23.3
Surface (tilled)	Manure	60	6.5
		120	7.9
		180	11.6
Surface (no-tilled)	Manure	60	6.2
		120	8.7
		180	9.1
Surface (tilled)	Commercial	60	9.0
		120	12.1
		180	19.3
Contrasts			
Fertilized versus controls			**
Manure injected versus surface (tilled) X N rate linear			*

***, **, * - significant at the 0.01, 0.05, 0.1 probability levels, respectively; NS – non-significant; NA-not applicable

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