Wheat Yield And Soil Response To Biosolids And Urea

M. Mozaffari, N.A. Slaton, J.R. Long and C. Kennedy

BACKGROUND INFORMATION AND RESEARCH PROBLEM

Soft red winter wheat (*Triticum aestivium* L.) yield is usually limited by nitrogen (N) deficiency more than any other nutrient. Thus, N fertilization is widely practiced to optimize wheat grain yield and quality. High synthetic fertilizer prices and recent interest in improving soil quality have resulted in a renewed interest in alternative high-organic matter fertilizers. Biosolids are high-organic matter byproducts of wastewater sludge treatment and contain plant essential nutrients such as N, P, and trace amounts of micronutrients. Utilization of biosolids as a source of plant nutrients is a sustainable practice that reduces the need for landfill space, recycles nutrients in the agroecosystem, and may improve soil quality. Most of the N in biosolids is in the organic form. Nitrogen availability from biosolids during a cropping season will depend on N-mineralization rate in soil, which is controlled by factors such as organic amendment properties, temperature, moisture, soil physical and chemical properties, amount of crop residue, and other characteristics of the cropping system. A review of literature shows a wide range of N mineralization rates for various biosolids in different regions and cropping systems and highlights the need for local studies on nutrient availability from biosolids (Barbarick et al., 1996; Binder et al., 2002).

A heat-dried, pelleted biosolid is being marketed in Arkansas by some fertilizer dealers under the trade name of Top Choice Organic (TCO, http://manncofertilizer.com/products.html)[1] with a minimum guaranteed chemical analysis of 5-3-0. Information on soil and crop response to TCO under soil and cropping conditions of Arkansas will benefit growers who may consider using TCO as an alternative fertilizer source. During the 2007-2008 growing season, we conducted a replicated field experiment to evaluate the effect of TCO in combination with urea on wheat grain yield and soil chemical properties.

PROCEDURES

The field experiment was conducted during the 2007-2008 cropping season on a Convent silt loam (Endoaquepts) at the University of Arkansas Lon Mann Cotton Research Station in Marianna, Ark. The Convent soil is an alluvial silt loam typical of soils used for wheat production in the Mississippi River Delta Region of Arkansas. The experimental site was planted in grain sorghum (*Sorghum bicolor* L.) in the summer of 2007 and sorghum residue was baled and removed before planting wheat. Agricultural limestone had been applied in spring of 2007 at the rate of 2 ton/acre. The experimental area was fertilized with triple superphosphate, muriate of potash, and elemental sulfur to supply 40 lb P_2O_5, 60 lb K_2O, and 20 lb S/acre to ensure that wheat yields were not limited by P, K, or S availability.

Soil samples were collected from the 0- to 6-inch depth prior to planting and fertilization and composited by replicate. Soil samples were processed and extracted with Mehlich-3 solution and the concentration of elements in the extract was measured by inductively coupled plasma atomic emission spectroscopy (Table 1). Soil nitrate (NO_3-N) was extracted with aluminum sulfate and measured with a specific-ion electrode (Donahue, 1992). Soil pH was measured in a 1:2 (volume: volume) soil-water mixture. Soil particle size analysis was performed by the hydrometer method (Arshad et al., 1996). In July 2008, following wheat harvest, soil samples were again collected from the 0- to 6-inch depth of selected plots and analyzed for the chemical properties described previously to determine how biosolid and urea amendments influenced soil chemical properties.

Sub-samples (n=6) of biosolid were analyzed by the University of Arkansas Agricultural Diagnostic Laboratory by standard methods described by Peters et al. (2003). The results of chemical analysis of biosolids were used to determine the amount of TCO needed to supply the required N rates. The average biosolid properties were pH 5.8, electrical conductivity 5217 µmhos/cm, 37.1% C, 0.2% K (0.24% K_2O), 2.0% P (4.58% P_2O_5), 1.8% Ca, 6.2% total N, 24 ppm NO_3-N, and 1204 ppm NH_4-N.

The experimental design was a randomized complete block with a total of 19 treatments that were replicated five times. Treatments consisted of four fall N sources including: no fall N, 40 lb urea-N/acre, 40 lb total N/acre as TCO, and 80

[1] Mention of a trade name is for facilitating communication only. It does not imply any endorsement of a particular product by the authors or the University of Arkansas, or exclusion of any other product that may perform similarly.

lb total-N/acre as TCO with 4 or 5 late-winter/early-spring N rates of 40 to 160 lb total N/acre in 40 lb N increments (Table 2). The late-winter N was applied in single (40 lb N/acre) or split applications (rates >40 lb N/acre) on 7 February and 17 March 2008. Biosolid was applied at 666 and 1322 lb/acre to supply the 40 and 80 lb total-N/acre, respectively. All preplant-applied fertilizers and biosolids were broadcast on 31 October 2007 and mechanically incorporated within a few hours. Individual plots were 23-ft long, 7.5-ft wide, and contained 10 rows of wheat with 7.5-inch-wide row spacings.'Pioneer 26R22' wheat was drill seeded at 120 lb/acre on 31 October 2007. Winter wheat was managed using practices recommended by the University of Arkansas Cooperative Extension Service. The entire plot was harvested with a small-plot combine on 13 June 2008. Harvested grain was adjusted to a uniform moisture content of 13% before statistical analysis was performed.

Analysis of variance was performed using the GLM procedure of SAS to evaluate wheat grain yield and soil chemical property responses to fall N source and total-N rate. When appropriate the Waller-Duncan minimum significant difference (MSD) test was used to separate significant treatment means at significance level of 0.10.

RESULTS AND DISCUSSION

Grain Yield

Nitrogen application significantly increased wheat yield, highlighting the importance of N fertilization for producing optimum wheat yields (Table 3). Wheat yields in all treatments receiving N fertilizer ranged from 48 to 88 bu/acre and were significantly greater than the yield of wheat receiving no N (38 bu/acre). Statistically, application of 120 to 160 lb total-N/acre generally produced near maximal wheat yields. Fall applications of 40 lb N/acre as urea and TCO were equally effective in increasing wheat yield as long as they were used in combination with sufficient N applied in late winter. Comparison of like total-N rates (Table 2) among fall N sources showed fall N application (at planting) had no significant benefit to wheat yield. Wheat grain yields receiving 80 and 120 lb N/acre produced 60 and 100% greater yields, respectively, than wheat receiving no N.

Soil Chemical Properties

Soil pH, organic matter, and Mehlich-3-extractable K, Ca, Mg, Cu, and Zn were not affected significantly by fertilization treatments. However, soil NO_3-N and Mehlich-3-extractable P were significantly affected (Table 4). Soil NO_3-N tended to increase as late-winter, urea-N rate increased and was greater for fall-applied TCO than fall-applied urea. Mehlich-3 soil-test P in soil receiving either no fall N or 80 lb total-N/acre as TCO averaged 55 and 69 ppm, respectively. These soil-test results indicate that TCO is a potential source of N and P.

PRACTICAL APPLICATION

This single site-year of study suggests that N application was necessary to produce maximal wheat grain yield. Grain yields of wheat receiving N-fertilizer were significantly higher than wheat receiving no N, regardless of fall-N source and total-N rate. Under the conditions of this experiment, fall application of urea and pelleted biosolids was equally effective in promoting wheat yield as long as crops were supplemented with sufficient late-winter urea-N. Fall application of TCO at rates ≥80 lb total N/acre increased available soil NO_3-N and P. Given the diversity of soils and wheat cropping systems in eastern Arkansas, additional research at multiple sites is needed to evaluate the consistency of these results.

ACKNOWLEDGMENTS

Research was funded by a gift from MANCO Fertilizers, Inc. We wish to thank the staff of the Lon Mann Cotton Research Station and the University of Arkansas Soil Testing and Research Laboratory for their assistance. The University of Arkansas Division of Agriculture also provided support.

LITERATURE CITED

Arshad, M.A., B. Lowery, and B. Grossman. 1996. Physical tests for monitoring soil quality. pp. 23-141. *In:* J.W. Doran and A.J. Jones (eds.). Methods for assessing soil quality. SSSA Spec. Publ. 49. SSSA, Madison, Wis.

Barbarick, K.A., J.A. Ippolito, and D.G. Westfall. 1996. Distribution and mineralization of biosolids nitrogen applied to dryland wheat. J. Environ. Qual. 25:796-801.

Binder, D.L., A. Doberman, D.H. Sanders, and K.G. Cassman. 2002. Biosolids as nitrogen source for irrigated maize and rainfed sorghum. Soil Sci. Soc. Am. J. 66:531-543.

Donahue, S.J. 1992. Determination of nitrate-nitrogen by specific-ion electrode. Reference soil media dagnostics for the Southern Region of the United States. p.25-27. Southern Cooperative Bulletin 347. University of Georgia College of Agriculture Experiment Station. Athens, Ga.

Peters, J., S. Combs, B. Hoskins, J. Jarman, J. Kovar, M. Watson, A. Wolf, and N. Wolf. 2003. Recommended methods for manure analysis (A3769). University of Wisconsin Cooperative Extension Service. Madison, Wis.

Table 1. Selected soil chemical property means (0- to 6-inch depth) of samples taken before planting wheat at the University of Arkansas Lon Mann Cotton Research Station in Marianna, Ark., on a Convent silt loam in October 2007.

Soil	Soil	Mehlich-3-extractable nutrients							Soil particle size			
pH[z]	NO_3-N[y]	P	K	Ca	Mg	Cu	Zn	SOM[x]	Sand	Silt	Clay	Texture
	(ppm)								(%)			
7.2	20	49	78	1382	304	1.5	3.0	1.26	9	77	14	silt loam

[z] Soil pH was measured in a 1:2 (volume:volume) soil-water mixture.
[y] NO_3-N measured by ion-specific electrode.
[x] SOM, soil organic matter determined by weight loss on ignition.

Table 2. List of N sources, rates, and application dates for a field experiment conducted at the Lon Mann Cotton Research Station in 2007-2008 to evaluate wheat and soil response to fall application of N from Top Choice Organic (TCO)™ biosolid and urea.

Fall 2007 N application		Late-winter 2008 N application		
N Source	N rate	1st application (7 February)	2nd application (17 March)	Total N applied (fall + winter)
	(lb N/acre)			
None	0	0	0	0
None	0	40	0	40
None	0	40	40	80
None	0	80	40	120
None	0	80	80	160
Urea	40	0	0	40
Urea	40	40	0	80
Urea	40	40	40	120
Urea	40	80	40	160
Urea	40	80	80	200
TCO	40	0	0	40
TCO	40	40	0	80
TCO	40	40	40	120
TCO	40	80	40	160
TCO	40	80	80	200
TCO	80	0	0	80
TCO	80	40	0	120
TCO	80	40	40	160
TCO	80	80	40	200

Table 3. Effect of fall-applied, N-fertilizer source and late-winter-applied N rate on wheat grain yield in a trial conducted at the University of Arkansas Lon Mann Cotton Research Station in Marianna, Ark., on a Convent silt loam during the 2007-2008 cropping season.

Fall N	N application time and rate			Wheat
source	Fall N	Late-winter N	Total N	grain yield
	(lb N/acre)			(bu/acre)
None	0	0	0	38 i[z]
None	0	40	40	54 gf
None	0	80	80	66 dc
None	0	120	120	79 b
None	0	160	160	80 b
Urea	40	0	40	48 h
Urea	40	40	80	59 ef
Urea	40	80	120	79 b
Urea	40	120	160	80 b
Urea	40	160	200	88 a
TCO	40	0	40	49 hg
TCO	40	40	80	62 de
TCO	40	80	120	79 b
TCO	40	120	160	82 ab
TCO	40	160	200	84 ab
TCO	80	0	80	60 def
TCO	80	40	120	69 dc
TCO	80	80	160	81 b
TCO	80	120	200	84 ab
			P-value	<0.0001

[z] Means followed by the same letter are not statistically different at P=0.10 probability level.

Table 4. The effect of fall N source/rate and late-winter N rate on selected soil chemical property (0- to 6-inches) means for soil collected post-harvest in selected treatments on a Convent silt loam during the 2007-2008 cropping season.

Fall N	N application rate			Soil chemical property								
source	Fall N	Winter N	Total N	pH[z]	SOM[y]	NO_3-N[x]	P	K	Ca	Mg	Cu	Zn
	(lb N/acre)				(%)	(ppm)						
None	0	0	0	7.2	1.7	6	55	88	1210	260	1.7	1.4
Urea	40	0	40	7.4	1.7	10	55	84	1284	269	1.7	1.4
Urea	40	40	80	7.5	1.7	17	53	82	1305	283	1.7	3.7
Urea	40	80	120	7.2	1.6	19	50	80	1275	284	1.7	3.8
TCO	40	0	40	7.4	1.7	8	60	75	1321	176	1.8	4.0
TCO	40	40	80	7.3	1.7	16	58	77	1272	273	1.7	3.6
TCO	40	80	120	7.2	1.6	24	52	74	1251	267	1.8	4.0
TCO	80	40	120	7.3	1.7	24	69	89	1294	280	1.9	4.3
P value				0.5020	0.7257	<0.0001	0.0339	0.4433	0.3724	0.3879	0.1590	0.9233
MSD at 0.10[w]				NS	NS	5	9	NS	NS	NS	NS	NS

[z] Soil pH was measured in a 1:2 (volume:volume) soil-water mixture.
[y] SOM, soil organic matter determined by weight loss on ignition.
[x] NO_3-N measured by ion-specific electrode.
[w] Minimum Significant Difference as determined by Waller-Duncan Test at P=0.10. NS, not significant at 0.10.