

## **TURKEY LITTER EFFECTS ON SUGAR BEET PRODUCTION**

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Livestock operations, mainly poultry and swine, are increasing in size and impact in the Southern Minnesota sugar beet growing area. Many sugar beet producers own or have interest in these operations; thus have manure available to use on their fields. Manure research data concludes that manure has a positive effect on crop production from its effects on soil nutrient availability and soil physical properties. A concern has been raised about the effect of late season nitrogen mineralized from the manure on sugar beet quality. Grower observations indicate better growth in fields that have had manure applied. With the large amount of manure available, the question has changed from whether to use manure but when in the sugar beet crop rotation should manure be applied to minimize quality concerns and realize benefits? Turkey manure has a considerable amount of litter in it, thus slowing initial release of poultry manure-N. The implication of the manure-N release is critical, especially to sugar beet growers. Therefore, recommendations need to be evaluated with sugar beets. This research project has been designed to: 1) determine when in a three-year rotation, should turkey litter be applied and 2) determine nitrogen fertilizer equivalent of turkey litter applied two and three years in advance of sugar beet production.

### Materials and Methods

To meet the objectives of this experiment, the first of three sites was established near Raymond, Minnesota in the fall of 2006. A second site was established in the fall of 2007 near Olivia, Minnesota and a third site was established near Bird Island in 2009. The Bird Island site was lost because of an errant manure application by the cooperator. A fourth site was established near Clara City, MN in the fall of 2009.

The Raymond site was cropped to soybean in 2007. Turkey manure was applied fall 2006 and soybean grain yields were harvested by a plot combine and soil samples taken in the fall of 2007. The treatments for the second year were applied to the first site near Raymond in the fall of 2007 with corn grown in 2008. The corn was harvested, soil samples taken, and the third year treatments were applied late fall 2008 and sugar beet was grown in 2009.

The second site near Olivia, Minnesota had the first manure treatment applied in the fall of 2007 with soybean grown in 2008. The soybeans were harvested with a research combine, soil samples taken, and the second year's treatments were applied fall 2008. Corn was grown in 2009 and hand harvested for grain yield fall 2009. After corn harvest, soil samples were taken and the third year treatments were applied and sugar beet was grown in 2010.

The fourth site near Clara City, Minnesota was cropped to dry edible beans in 2010 by request of the grower. The dry beans were hand harvested in the fall of 2010 and the turkey litter treatments of 3 and 6 tons were applied after harvest.

At each site of this study there were five replications of the treatments listed in Table 1. Turkey litter treatments of 3 and 6 tons per acres were applied 2 and 3 years ahead of sugar beet production in the three year rotation of soybean (dry bean)/corn/sugar beet. This rotation is the most common rotation in the Southern Minnesota Sugar Cooperative growing area. Treatment 5 is the check treatment for the whole experiment while treatments 8 and 15 are checks for different parts of the rotation. Treatments 6 through 14 are the N fertilizer rates plus the two turkey litter rate applied the fall before the sugar beet production year. During the corn production year, 120 lb N per acre will be applied for treatments 6 through 14. This is the current U of MN N guideline for corn following soybean. In the soybean production year, grain yield was measured with a research combine. Soil samples were taken in fall to a depth of 4 feet and analyzed for nitrate-N while soil samples to a 6 inch depth were analyzed for phosphorous, potassium, organic matter, and pH. The year 2 manure and fertilizer treatments were

applied in the late fall. Corn grain was hand harvested in the fall. Similar to year 1 soil samples were taken. The year 3 treatments were applied late fall of year 2. Root yield and quality were determined in the fall. In each of the production years, optimum production practices for pests control and nutrient management besides nitrogen were used.

Table 1. Treatment List

Treatment Number	Year 1 (soybean/dry bean)	Year 2 (corn)	Year 3 (sugar beet)
1	3 ton litter	0 N	0 N
2	6 ton litter	0 N	0 N
3	0 N	3 ton litter	0 N
4	0 N	6 ton litter	0 N
5	0 N	0N	0 N
6	0 N	120 N	3 ton litter
7	0 N	120 N	6 ton litter
8	0 N	120 N	0 N
9	0 N	120 N	30 N
10	0 N	120 N	60 N
11	0 N	120 N	90 N
12	0 N	120 N	120 N
13	0 N	120 N	150 N
14	0 N	120 N	180 N
15	0 N	0 N	90 N

Table 2. Timeline for crops at each of three locations.

2007-08	2008-09	2009-10	2010-2011	2011-2012	2012-2013
Location 1 - soybean	Location 1 - corn	Location 1 – sugar beet			
	Location 2 - soybean	Location 2 - corn	Location 2 – sugar beet		
		Location 3 - Abandoned	Location 4 – dry edible bean	Location 4 - corn	Location 4 – sugar beet

## Results and Discussion

### Raymond Site:

Soybean grain yields were significantly increased by the application of manure in 2007 at the Raymond site, Table 3. This increase was small. There were no differences in grain yield between 3 and 6 tons of turkey litter application.

Table 3. Soybean grain yields as affected by the application of 3 and 6 tons of turkey litter in fall 2006 at Raymond, Minnesota in 2007.

Treatment	Soybean grain yield (bushels per acre)
Zero (check)	50.0
3 tons turkey litter	51.8
6 tons turkey litter	53.5
Statistics	P>F
Zero vs turkey litter application	0.005
Manure (3 vs 6 tons turkey litter)	NS
C.V. (%)	5.3

Soil samples were taken in the fall before each year of the rotation. The soil nitrate-N, soil test P, and soil test K were similar in the fall of 2006 before the study started at this site, Table 4. The application of 3 and 6 tons of turkey litter, fall 2006, increased the soil residual nitrate-N and soil test P in the sample taken fall 2007, Table 4. The application of turkey litter at 6 tons per acre two and three years before sugar beet production increased soil nitrate-N.

Table 4. Soil test results fall 2006, fall 2007, and fall 2008 at Raymond, Minnesota.

Treatment	Nitrate-N 0-4 ft. (lb/A)			Olsen-P (ppm)			Soil test K (ppm)		
	Fall 06	Fall 07	Fall 08	Fall 06	Fall 07	Fall 08	Fall 06	Fall 07	Fall 08
3 tons turkey litter fall 06	24	98	37	35	38	34	206	178	136
6 tons turkey litter fall 06	22	172	71	34	45	41	196	187	146
3 tons turkey litter fall 07			29			28			135
6 tons turkey litter fall 07			79			43			169
120 lb N/A fall 07			40			35			143
Check	23	44	26	27	29	31	165	157	141

Corn grain yields in 2008 were measured at the Raymond site, Table 5. The only significant difference in corn grain yield was between the check, with no N fertilizer or turkey litter applied and the corn grain yield from the rest of the treated plots. There were no differences between yields from the 120 pounds N per acre as urea fertilizer and the turkey litter treatments from applied either Fall 2006 or Fall 2007, Table 4. In the Fall of 2008, soil nitrate-N was increase over the check in plots that were treated with 6 tons of turkey litter fall 2006 or fall 2007. The 3 tons of turkey applied in fall 2006 or fall 2007 had similar soil nitrate-N values as the check.

Table 5. Corn grain yields as affected by the application of 120 pounds N per acre, 3 and 6 tons of turkey litter in fall 2006, and 3 and 6 tons of turkey litter in fall 2007 at Raymond, Minnesota in 2008.

Treatment	Corn grain yield (bushels per acre)
Zero N (check)	102
120 pounds N per acre applied fall 2007	150
3 tons turkey litter applied fall 2006	130
6 tons turkey litter applied fall 2006	146
3 tons turkey litter applied fall 2007	150
6 tons turkey litter applied fall 2007	144
Statistics	P > F
Check vs rest	0.0001
120 lb N per acre vs turkey litter	NS
2006 vs 2007 turkey litter	NS
2006 3 ton vs 6 ton turkey litter	NS
2007 3 ton vs 6 ton turkey litter	NS

Sugar beets were planted in 2009 with N rate treatments and 3 and 6 turkey litter applications made fall 2008. The root yield, extractable sucrose per ton, extractable sucrose per acre, and revenue for the turkey litter treatments are reported in Table 6 while the statistical analysis is reported in Table 7. Root yield was increased with the use of litter application. The increase was greatest with the Fall 2008 litter application. This application was confounded with an application of 120 pounds of fertilizer N per acre. The sugar beet root yield greater with 6 tons litter per acre applied compared to the 3 tons per acre when the litter was applied fall 2007. Sugar beet quality, as measured by the extractable sucrose per ton of processed sugar beet was not affected by the manure treatments. Because of the lack of response in sugar beet quality, extractable sucrose per acre and revenue was affected by the litter treatments the same as root yield was.

Table 6. Sugar beet root yield, extractable sucrose per ton, extractable sucrose per acre, and revenue as affected by the application of turkey litter since 2006 at Raymond, MN in 2009.

Treatments			Root yield	Extractable sucrose		Revenue
Fall 06	Fall 07	Fall 08	ton/A	lb/ton	lb/A	\$/A
Check	Check	Check	23.1	248	5721	629
3 ton turkey litter			27.3	241	6574	701
6 ton turkey litter			27.6	250	6994	786
	3 ton turkey litter		25.1	247	6207	680
	6 ton turkey litter		33.9	253	8527	949
	120 lb N/A	3 ton turkey litter	35.1	252	8816	982
	120 lb N/A	6 ton turkey litter	39.3	258	10102	1149

Table 7. Statistical analysis for sugar beet root yield, extractable sucrose per ton, extractable sucrose per acre, and revenue at Raymond, MN in 2009.

Contrast	Root yield	Extractable sucrose		Revenue
		lb/ton	lb/A	
		P>F		
Check vs rest	0.0007	NS	0.0005	0.0008
Turkey litter fall 06 and 07 vs 08	0.0001	0.12	0.0001	0.0001
Turkey litter fall 06 vs fall 07	NS	NS	NS	NS
Turkey litter 06, 3 vs 6 tons	NS	0.17	NS	NS
Turkey litter 07, 3 vs 6	0.002	NS	0.002	0.003
Turkey litter 08, 3 vs 6	NS	NS	0.20	0.17
N rate fertilizer	0.02	NS	0.04	0.08

To compare litter treatments with fertilizer, a nitrogen rate study was conducted within the litter treatments, Table 8. There was a significant response to nitrogen application at the Raymond, MN site in 2009 for root yield, extractable sucrose per acre, and revenue. Sugar beet quality was not affected by N fertilizer application. The optimum nitrogen rate was 90 pounds per acre. The residual nitrate-N in the surface 4 feet was 40 pounds per acre. With both soil nitrate-N and fertilizer N, this would make the optimum of 130 pounds per acre. The optimum fertilizer application was similar statistically to the best litter application for revenue. This information would suggest that the time of turkey litter application in the sugar beet rotation was important at this location. Remember that this observation is based on one location in one year!

Table 8. Sugar beet root yield, extractable sucrose per ton, extractable sucrose per acre, and revenue as affected by the application of nitrogen fertilizer fall 2008 at Raymond, MN in 2009.

Fall 07	Fall 08	Root yield	Extractable sucrose		Revenue
lb nitrogen/A		ton/A	lb/ton	lb/A	\$/A
120	0	27.0	254	6884	776
120	30	25.7	254	6553	740
120	60	33.2	254	8448	950
120	90	35.1	255	8985	1017
120	120	30.5	259	7871	899
120	150	33.4	255	8484	955
120	180	31.3	248	7754	850

**Olivia Site:**

A second site was established south of Olivia fall of 2007. Soybean was planted and harvested in 2008. The soybean grain yields were not affected by the 3 and 6 tons turkey litter application in the fall of 2007, Table 9.

Table 9. Soybean grain yields as affected by the application of 3 and 6 tons of turkey litter in fall 2007 at Olivia, Minnesota in 2008.

Treatment	Soybean grain yield (bushels per acre)
Zero (check)	49.8
3 tons turkey litter	50.1
6 tons turkey litter	50.7
Statistics	P>F
Zero vs turkey litter application	NS
Manure (3 vs 6 tons turkey litter)	NS
C.V. (%)	6.0

Soil samples were taken each fall before each crop in the rotation, Table 10. The average amount of nitrate-N in 4 feet at the beginning of this study at this site was 100 pounds per acre. The phosphorus was near 50 ppm Olsen and soil test was 170 ppm. The application of turkey litter at 6 tons per acre caused a greater soil nitrate amount in the fall of 2008. The soil test phosphorus was increased while soil test K was not affected by the fall 2007 manure applications. The study area was fertilized in

the fall of 2008 with 80 pounds phosphate per acre as 0-46-0 and 60 potash per acre as 0-0-60. This application resulted in the increase in soil test P and soil test K between the falls of 2008 and 2009. The increases caused the fall soil test P and K to be similar among the different treatments.

Table 10. Soil test results fall 2007, fall 2008, and fall 2009 at Olivia, Minnesota.

Treatment	Nitrate-N 0-4 ft. (lb/A)			Olsen-P (ppm)			Soil test K (ppm)		
	Fall 07	Fall 08	Fall 09	Fall 07	Fall 08	Fall 09	Fall 07	Fall 08	Fall 09
3 tons turkey litter fall 07		48	27	48	70	96	164	174	287
6 tons turkey litter fall 07	118	101	20	56	68	82	177	186	231
3 tons turkey litter fall 08			24			79			255
6 tons turkey litter fall 08			26			68			265
120 lb N/A fall 08			20			91			281
Check	80	47	22			83			268

Corn was grown in 2009 with treatments added of 120 pounds N per acre and 3 and 6 tons turkey litter applied fall 2008. Corn grain yields from 2009 are reported in Table 11. There was a significant increase in grain yield over no nitrogen from the application of turkey litter and nitrogen fertilizer in 2009. The 120 pounds of N per acre as urea and the 6 tons of turkey litter per acre applied fall 2008 had the greatest grain yields of 218 bushels per acre. Statistically, there was no difference in grain yield between the 2007 and 2008 turkey litter applications. Each year, the 6 ton per acre application produced greater grain yields than the 3 ton per acre application. This site will be planted to sugar beet in 2010.

Table 11. Corn grain yields as affected by the application of 120 pounds N per acre, 3 and 6 tons of turkey litter in fall 2007, and 3 and 6 tons of turkey litter in fall 2008 at Olivia, Minnesota in 2009.

Treatment	Corn grain yield (bushels per acre)
Zero N (check)	149
120 pounds N per acre applied fall 2008	218
3 tons turkey litter applied fall 2007	180
6 tons turkey litter applied fall 2007	208
3 tons turkey litter applied fall 2008	185
6 tons turkey litter applied fall 2008	218
Statistics	P > F
Check vs rest	0.0001
120 lb N per acre vs turkey litter	0.0013
2007 vs 2008 turkey litter	NS
2007 3 ton vs 6 ton turkey litter	0.05
2008 3 ton vs 6 ton turkey litter	0.03

Sugar beets were planted in 2010 with N rate treatments and 3 and 6 turkey litter applications made fall 2009. The root yield, extractable sucrose per ton, extractable sucrose per acre, and revenue for the turkey litter treatments are reported in Table 12. while the statistical analysis is reported in Table 13. Root yield was increased with the use of litter application. The increase was greatest with the Fall 2009 litter application. This application was confounded with an application of 120 pounds of fertilizer N per acre. The increase in root yield with 120 pounds of N fertilizer N per acre was 24 tons per acre. This suggests that the manure application in fall 2009 did increase root yield more than the applications in previous years. Sugar beet quality, as measured by the extractable sucrose per ton of processed sugar beet was decreased by the manure treatments compared to sugar beet grown in plots with no nitrogen fertilizer application during the three years of the rotation. There were no differences in extractable sucrose by the different manure treatments. The extractable sucrose and revenue per acre were affected by the treatments, similarly. The increase in root yield over the check resulted in an increase in both extractable sucrose per acre and revenue per acre from manure applications. The fall 2009 manure application (either rate) increased root yield over the other manure treatments and thus increased the extractable sucrose per acre and revenue per acre more than the other manure treatments. The best return per acre was from the manure applied directly before the sugar beet production year at this location.

Table 12. Sugar beet root yield, extractable sucrose per ton, extractable sucrose per acre, and revenue as affected by the application of turkey litter since 2007 at Olivia, MN in 2010.

Treatments			Root yield	Extractable sucrose		Revenue
Fall 07	Fall 08	Fall 09	ton/A	lb/ton	lb/A	\$/A
Check	Check	Check	20.3	308	6208	813
3 ton turkey litter			25.7	279	7193	879
6 ton turkey litter			27.2	277	7532	913
	3 ton turkey litter		27.1	275	7480	903
	6 ton turkey litter		28.3	271	7695	918
	120 lb N/A	3 ton turkey litter	37.3	280	10466	1282
	120 lb N/A	6 ton turkey litter	35.0	274	9615	1158

Table 13. Statistical analysis for sugar beet root yield, extractable sucrose per ton, extractable sucrose per acre, and revenue at Olivia, MN in 2010.

Contrast	Root yield	Extractable sucrose		Revenue
		lb/ton	lb/A	
		P>F		
Check vs rest	0.0001	0.0001	0.0004	0.06
Turkey litter fall 07 and 08 vs 09	0.0001	0.59	0.0001	0.0001
Turkey litter fall 07 vs fall 08	0.21	0.15	0.49	0.74
Turkey litter 07, 3 vs 6 tons	0.32	0.65	0.48	0.60
Turkey litter 08, 3 vs 6	0.37	0.38	0.63	0.81
Turkey litter 09, 3 vs 6	0.12	0.21	0.08	0.07
N rate fertilizer	0.0004	0.003	0.06	0.21

The use of fertilizer applied in fall 2009 increased root yield and extractable sucrose per acre, Table 14. Revenue per acre was not affect by the N application. The decrease in extractable sucrose per ton was more pronounced for fertilizer application rates when compared to the litter treatments.

Table 14. Sugar beet root yield, extractable sucrose per ton, extractable sucrose per acre, and revenue as affected by the application of nitrogen fertilizer fall 2009 at Olivia, MN in 2010.

Fall 08	Fall 09	Root yield	Extractable sucrose		Revenue
lb nitrogen/A		ton/A	lb/ton	lb/A	\$/A
120	0	24.0	274	6582	792
120	30	23.6	282	6581	802
120	60	27.6	282	7631	938
120	90	24.3	275	6652	799
120	120	28.5	266	7556	884
120	150	27.1	257	6972	792
120	180	27.7	265	7348	859

### Clara City site:

The Clara City site was established with the application of the 3 and 6 tons of turkey litter in the fall of 2009. The plot area was planted to dry edible bean in 2010. This is different than the other sites. The dry edible bean was hand harvested. The use of turkey significantly increased bean yields in 2010, Table 15. The increase was approximately 600 lb per acre. There was no difference in bean yield from the different turkey litter rates.

Table 15. Dry edible bean yields as affected by the application of 3 and 6 tons of turkey litter in fall 2009 at Clara City, Minnesota in 2010.

Treatment	Dry edible bean yield (lbs per acre)
Zero (check)	1902
3 tons turkey litter	2465
6 tons turkey litter	2575
Statistics	P>F
Zero vs turkey litter application	0.03
Manure (3 vs 6 tons turkey litter)	0.69
C.V. (%)	18.0

**Summary:**

After two sites worth of information, if a grower must apply turkey litter in the sugar beet production system, it should be applied in the fall before sugar beet production. This conclusion is not what the current recommendation is. This study has one more site to complete. This will occur at the end of the 2012 growing season.