NITROGEN VALUE OF POTATO AND ONION SLUDGE FOR CORN PRODUCTION

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Summary

Three alternative treatments to provide nitrogen-potato sludge, a mixture of potato and onion sludge, and a chemical N fertilizer-were applied to a bench soil. Bench soils are of low fertility and are located on the benches above the deep, fertile alluvial soils in the valley bottom. The two sludge treatments were applied and incorporated before planting field corn. The sludges were applied at a rate to result in 200 lb N/acre available to the corn, based on the anticipated mineralization rate of the sludges. The chemical N fertilizer was sidedressed after planting at 200 lb N/acre. Sludge amended and chemical N fertilized plots had significantly higher forage and grain yields than did the unfertilized check plots. Both the sludge amended plots and the plots treated with chemical N fertilizer produced favorable yield and quality of forage and grain.

Introduction

The processing of potatoes into frozen French fries generates a substantial amount of liquefied refuse. This refuse is partially dehydrated resulting in a sludge the consistency of gelatin (80% moisture). Another waste of agricultural industry results from the extraction of onion oil from cull onions; the resulting sludge is not dehydrated. The disposal of these sludges incurs costs to the processors. With increased restrictions and costs of landfill disposal, application of the sludges to agricultural land could be an alternative. To establish guidelines for application, waste mineralization rates in soil and their effect on crop yields needs to be determined. The land application of the sludges could not only benefit the processors, but could also benefit the growers by allowing lower cost sludge to substitute for chemical fertilizers. Since the onion sludge is not dehydrated, the application of pure onion sludge is difficult. The mixture of potato and onion sludges, however, results in a consistency that is practical for land application. This trial tested the effect of potato sludge or a mixture of potato and onion sludges on field corn yield, quality, and N recovery.

Materials and Methods

The trial was conducted on Nyssa silt loam with 1.5% organic matter, a pH of 8.1, and 23 ppm P, 137 ppm K, 2690 ppm Ca, 330 ppm Mg, 156 ppm Na, 1.7 ppm Zn, 12.8 ppm Fe, 5.8 ppm Mn, 1 ppm Cu, 10 ppm SO_4-S, and 0.5 ppm B.

The 4 treatments were an unfertilized check, potato sludge, potato/onion sludge mix, and N fertilizer. The experimental design was a randomized complete block with five replicates. The plots were 20 rows wide and 50 feet long.

The sludge application rate was determined by having a target of 200 lb/acre of available N released the first year based on a 20 percent N mineralization rate. The potato sludge had a 20 percent dry matter (DM) content and 5.52 percent N (DM basis) and the mixed sludge had a 11.9 percent dry matter content and 4.83 percent N. The potato sludge was applied at 50 tons/acre (wet weight) and the potato/onion sludge mix was applied at 100 tons/acre (wet weight). The proportion of the sludges in the mix was 44% potato and 56% onion by weight and was based on the annual output of the sludges from the respective processing facilities. The potato/onion sludge mix was prepared by weighing each sludge separately and then mixing both in a Rotomix feed truck (Rotomix Co., Dodge City, KS).

The potato sludge and the potato/onion sludge mix were applied on April 7 using a Terragator applicator (Ag. Chem. Ind. Div., Minetonka, MN) equipped with a Knight "Slinger box" (Knight Manufacturing, Brodhead, WI). The sludge was side discharged from the slinger box and broadcast by flails located in the discharge outlet. The Terragator was calibrated separately for the potato sludge and potato/onion sludge mix.

The field was disked and bedded to 30 inch centers on April 25. On May 6, a composite soil sample of all plots in each treatment from the first and second foot of soil was taken and air dried for determination of N mineralization by anaerobic incubation.

Alachlor at 3 lb ai/acre was broadcast and incorporated with a bed harrow on May 12. Seed of field corn variety 3489 (Pioneer) was planted on May 13 at 27,000 seeds/acre. The field was cultivated on June 4 and again on June 12 after sidedressing the N fertilizer plots. The N fertilizer plots had urea at 200 lb N/acre sidedressed on June 12, 30 days after planting. The field was furrow irrigated as necessary in alternate furrows with the irrigated furrows alternating at each irrigation.

Stand counts and plant heights were taken on June 18 in each plot. The mid-silk stage was determined for each plot by the number of plants in silk out of a sample of 20. Twenty-four first fully developed leaves were sampled on June 25 and 24. Leaves immediately above the ear node were sampled on August 1 (at silking) from the two rows adjacent to the central two rows in each plot. The leaf samples were analyzed for N, P, and K. The soil in each plot was sampled to a 6-foot depth in one foot increments in April before the sludge application and again after harvest.

Forage and grain harvest was started when the kernels reached approximately 30 percent moisture on October 1. All the plants in 10 feet of a row adjacent to the central harvest area in each plot were cut at ground level and weighed. The ears were removed and weighed and then the stalks and ears were shredded in a manner to result in a uniform mixture of the ears and stalks. A subsample of the shredded plants was taken for moisture content determination and total N analysis. All ears from the central 33 feet of the middle two rows in each plot were harvested, weighed, dried in a forced air drier, and then shelled with a Wintersteiger Nurserymaster small plot combine. The shelled corn was weighed and a subsample was taken for determination of moisture content. Shelled corn yields were corrected to 12 percent and 30 percent moisture. Subsamples of the whole shredded plants and of the shelled corn were analyzed for total N.

The soil was sampled in one-foot increments down to six feet in each plot before planting and after harvest and analyzed for nitrate and ammonium. The N balances were calculated by subtracting the post harvest accounted nitrogen (crop N uptake plus available soil N after harvest) from the nitrogen supply (available soil N in spring plus chemical fertilizer N plus N from irrigation water). Nitrogen contribution from the irrigation water was measured to be 1.5 ppm nitrate and ammonium-N or 8 lb N/acre-inch/acre of water infiltration assuming 2 acre-feet/acre of infiltration. Nitrogen contribution from organic matter mineralization was estimated by anaerobic incubation at 104 °F for 7 days.

Results and Discussion

Application of the sludges did not result in any differences in plant stand compared to the unfertilized check or to the N fertilizer treatments. Average plant stand was 18,687 plants/acre. The application of the sludges with the Terragator resulted in a uniform spreading on the soil surface. The 3-week period between the sludge application and the incorporation allowed for drying of the sludge, making the incorporation more effective, and avoiding any interference with seed emergence due to disuniform soil structure.

The check and N sidedressed plants were significantly shorter than the sludge treated plants on June 18 (Table 1).

The unfertilized check treatment plants had significantly lower leaf N concentration than the other treatments on June 25 and at silking on August 1 (Table 1). The leaf N concentration for the check plants at silking was below the sufficiency range.

The N fertilized plants had significantly lower leaf P concentration than the other treatments on June 25. With the P supply rate of the soil being the same for the check and N fertilized plants, the P in the faster growing N fertilized plants could have become diluted, compared to the slower growing check plants. The sludge treated plants

probably obtained a higher P supply from sludge mineralization. Leaf P and K concentrations at silk were within the sufficient range for all treatments.

The two sludge treatments and the N fertilizer treatment produced favorable grain yield (Table 2), grain total N, grain total protein, whole plant dry matter yield, whole plant total N, and whole plant total protein (Table 3) with no statistically significant difference. The unfertilized check treatment had significantly lower grain yield, grain total N, grain total protein, whole plant dry matter yield, whole plant total N, and whole plant total protein than the other treatments.

The soil available N balances were positive, both in the profile (0-6 feet, Table 4) and in the top 2 feet (Table 5), in order from lowest to highest: N fertilizer, unfertilized check, potato sludge, and sludge mix. The soil N balances suggest that sludge N mineralization released substantial available N. The N fertilizer treatment was probably subject to leaching.

Literature Cited

Jones, J.B., Jr., H.V. Eck, and R. Voss. 1990. Plant analysis as an aid in fertilizing corn and grain sorghum. p. 521-547. In: Westerman, R. L. (ed.) Soil testing and plant analysis. SSSA Book Series, no. 3. SSSA, Madison, WI.

Table 1. Plant height and nutrient concentration of first fully developed leaf on June 25 and of ear leaf at silking on August 1. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1997.

Treatment	June 18	Leaf nutrient concentration					
		June 25			August 1		
	Plant height	N	P	K	N	P	K
	feet	%					
Check	1.31	2.45	0.31	1.98	1.78	0.22	2.89
Potato sludge	1.82	2.89	0.34	2.06	2.91	0.27	2.87
Sludge mix[1]	1.84	2.95	0.34	2.22	3.00	0.27	2.86
N fertilizer	1.15	2.93	0.27	1.95	2.75	0.26	2.81
LSD (0.05)	0.26	0.35	0.04	NS	0.44	NS	NS
Sufficiency range[2]					2.1-4.0	0.18-0.5	1.7-3.0

[1]Potato/onion sludge mix (44%/56%)

[2]for ear leaves at silk according to Jones et al. (1990).

Table 2. Corn yield response to potato and onion sludge application compared to N fertilizer, Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1997.

		Grain yield	
	Grain moisture[2]	12% moisture	30% moisture
Treatment	%	----- bu/acre[3] -----	
Check	30.5	120.4	151.3
Potato sludge	32.1	195.0	245.1
Sludge mix[1]	31.4	218.2	274.3
N fertilizer	32.6	196.1	246.5
LSD (0.05)	NS	31.9	40.1

[1]Potato/onion sludge mix (44%/56%)

[2]at harvest

[3]56 lb/bu

Table 3. Forage yield, N content, and estimated protein content of corn in response to potato and onion sludge application compared to N fertilizer, Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1997.

	Kernel				Whole plant				
	Yield[1]	N content	Total N	Estimated protein[2]	Dry matter	DM yield	N content	Total N	Estimated protein[2]
Treatment	t/acre	%	---- lb/acre ----		%	t/acre	%	---- lb/acre ----	
Check	4.2	0.93	55.3	345	44.8	11,301	0.78	87.7	548
Potato sludge	6.9	1.31	123.7	773	44.9	16,048	0.92	147.6	922
Sludge mix[3]	7.7	1.24	133.2	833	43.9	17,074	0.97	165.4	1,034
N fertilizer	6.9	1.38	131.5	822	44.3	17,145	0.97	165.8	1,037
LSD (0.05)	1.1	NS	27	78	NS	2,013	0.11	24	150

[1]30% moisture

[2]Total N X 6.25

[3]Potato/onion sludge mix (44%/56%)

Table 4. Soil N balances for the 0 to 6 foot depth in response to land application of potato and onion sludges. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1997.

	N supply			Fall nitrogen accounting			
Treatment	Pre-plant soil available N (0-6')	Fertilizer N	N in irrigation water	Fall soil available N (0-6')	Plant N recovery	Accounted N	Balance[1]
	lb/acre						
Check	187.2	0	8	229.6	87.7	317.3	122.1
Potato sludge	182.9	0	8	259.8	147.6	407.3	216.4
Sludge mix[2]	168.9	0	8	335.6	165.4	501.0	324.1
N fertilizer	149.3	200	8	226.1	165.8	391.9	34.6
LSD (0.05)	22.7	-	-	46.1	24.0	45.4	58.2

[1]based on the difference between all N supplies and fall N accounting.

[2]Potato/onion sludge mix (44%/56%).

Table 5. Soil N balances for the 0 to 2 foot depth in response to land application of potato and onion sludges. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1997.

	N supply			Fall nitrogen accounting			
Treatment	Pre-plant soil available N (0-2')	Fertilizer N	N in irrigation water	Fall soil available N (0-2')	Plant N recovery	Accounted N	Balance[1]
	lb/acre						
Check	68.4	0	8	76.7	87.7	164.4	88.0
Potato sludge	71.0	0	8	104.1	147.6	251.6	172.6
Sludge mix[2]	55.7	0	8	167.5	165.4	332.9	269.2
N fertilizer	53.8	200	8	82.8	165.8	248.6	-13.2
LSD (0.05)	13.5			31.0	24.0	34.9	32.5

[1]based on the difference between all N supplies and fall N accounting.

[2]Potato/onion sludge mix (44%/56%).