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RESIDUAL EFFECTS OF PULP AND SPOILED BEET APPLICATION ON SUGAR BEET YIELDS AND SOIL NITROGEN AVAILABILITY

Kuldip Kumar, Carl J. Rosen, and Satish C. Gupta
Department of Soil, Water, and Climate
University of Minnesota, St. Paul, Minnesota

INTRODUCTION

Application of organic industrial wastes and by-products on agricultural land has received considerable attention in recent years not only because of increasing energy requirements for production of synthetic fertilizers, but also because of the cost and environmental problems associated with disposal methods. In this context, nutrient cycling in organic waste treated soils deserves attention as this may affect the use efficiency of applied fertilizers and may cause some environmental problems.

The sugar beet processing facility generates many solid and liquid by-products resulting from the processing of sugar beets into sugar. Application of sugar beet processing by-products to agricultural land has become a common practice to reduce disposal costs. Land application of sugar beet by-products like spoiled beets and pulp at rates greater then agronomic rates may cause some water quality concerns both for surface water and ground water. We are conducting field studies at East Grand Forks to assess the long-term production and environmental impacts of land applying sugar beet by-products.

The results of our ongoing experiments (Kumar *et al*., 2001 and Kumar *et al*., 2002) clearly show that in the first year of application these by-products immobilize soil inorganic N ,and at higher rates the by-products also cause poor crop establishment. Immobilization of soil N combined with poor crop establishment in the first year of by-product application caused reduction in the grain yield of a wheat crop by 40%. From an environmental standpoint, nitrate and ammonium concentrations in runoff and percolation waters were low (due to immobilization); however, high BOD, total P, and soluble P in runoff waters are matters of concern.

In this paper we report the residual effects of sugar beet by-products applied in 2001 on sugar beet yield, quality, and nitrogen (N) availability.

MATERIALS AND METHODS

The field experiments are being conducted at East Grand Forks. The soil characteristics, treatments and setup of the field experiment have already been described (see Kumar et al., 2001 Sugar beet Research and Extension Reports, p135-140). Briefly, the treatments applied in year 2001 were:

(i) Control (no by-product, no fertilizer)
(ii) Spoiled beets @ 100 t A^{-1}
(iii) Spoiled beets @ 200 t A^{-1}
(iv) Pulp @ 100 t A^{-1}
(v) Pulp @ 200 t A^{-1}

The characteristics of these by-products have been reported previously (Kumar *et al*., 2001). A crop of sugar beet was grown in the year 2002. No by-product was applied this year, however, the control treatment was fertilized with 100 lbs N A^{-1} (hereafter referred as Cont.-fert.) and an additional treatment un-fertilized control (Cont.-unfert.) was added in the buffer areas to estimate N availability. During each run-off event, water samples were collected and analyzed for water quality parameters. Soil samples were taken monthly at three soil depths (0-6, 6-12, and 12-18”) and to a depth of five and a half feet during fall 2002 after the harvest of sugar beets. These were analyzed for inorganic-N (NH_4^+-N + NO_3^--N). Sugar beet top growth, N content, root yield, and quality were measured at harvest. The American Crystal Sugar Quality laboratory at East Grand Forks analyzed beet samples for quality at harvest.

RESULTS AND DISCUSSION

Sugar beet root yield and quality:

There was no significant difference (P=0.10) in root yield between fertilized control and the by-product application treatments applied at the 200 t rate, while root yield in the unfertilized control treatment was significantly lower than 200 t rate by-product treatments but similar to 100 t rate treatments. This was probably due to sufficient greater release of N from higher rate treatments as compared with 100 t rate treatments during the second year of by-product application. Similarly, Kumar and Goh (2002) reported that substantial amounts of nutrients are released during the second year when crop residues of wide C/N ratio are incorporated in soil. Similar to root yield, maximum recoverable sucrose was obtained from the fertilized control treatment. In general, recoverable sugar yields in the fertilized control and by-product treatments were significantly greater than the unfertilized control treatments (Table 1). It was interesting to note that recoverable sucrose per ton roots was not significantly different among treatments. The sucrose concentration and loss to molasses was also not significantly different among treatments.

Table 1: Root yield, sucrose concentration, loss to molasses, recoverable sucrose per ton, and the recoverable sugar per acre.

Treatment	Root yield ton A^{-1}	Sucrose Conc. (%)	Loss to molasses (%)	Recoverable sugar	
				lb ton^{-1}	lbs A^{-1}
Cont.-fert.	20.9 A	17.9	1.4	330	6899 A
Beets 100 t A^{-1}	17.5 BC	17.7	1.4	327	5716 BC
Beets 200 t A^{-1}	18.6 AB	18.0	1.5	330	6126 AB
Pulp 100 t A^{-1}	17.8 BC	18.0	1.3	334	5936 B
Pulp 200 t A^{-1}	19.2 AB	17.6	1.5	322	6170 AB
Cont.-unfert.	15.5 C	17.7	1.5	324	4995 C
$LSD_{0.10}$	2.9	NS	NS	NS	897

Sugar beet top yield, N concentration and N uptake of roots and tops:

There was no significant difference in dry matter yield of sugar beet tops, N concentration in tops, and tops N uptake (Table 2). Similarly, there was no significant difference in root N concentration and root N uptake. However, total N uptake (tops+roots) showed significant differences among treatments. The fertilized control treatment showed maximum N uptake followed by the 200 t rate of both pulp and beets. The unfertilized control and the 100 t beet and pulp treatments had the lowest N uptake. The data clearly showed that there was higher N availability from pulp and beets when applied at the higher rate compared to lower rate.

Table 2: Sugar beet tops dry matter yield, N concentration, N uptake, roots N concentration and N uptake and total N uptake.

Treatment	Tops			Roots		Total N uptake
	Yield lbs	N Conc %	N uptake lbs A^{-1}	N conc %	N uptake lbs A^{-1}	lbs A^{-1}
Cont.-fert.	3412	2.28	77.9	0.50	53.3	131.2 A
Beets 100 t A^{-1}	2804	1.86	52.6	0.50	37.0	89.6 C
Beets 200 t A^{-1}	3562	1.92	67.3	0.50	46.3	113.6 B
Pulp 100 t A^{-1}	2807	1.73	48.7	0.44	49.0	97.7 C
Pulp 200 t A^{-1}	3324	1.90	64.1	0.49	46.6	110.7 B
Cont.-unfert.	2539	2.15	56.1	0.46	37.2	93.3 C
$LSD_{0.05}$	NS	NS	NS	NS	NS	12.0

Soil inorganic-N (0-18") during growing season:

Inorganic N content in the surface 0-18" of soil during the sugar beet growing season is presented in Table 3. During June, inorganic N in soil was significantly higher in the fertilized control compared with other treatments. The lowest soil inorganic N amount was present in the unfertilized control, which was statistically similar to that in the 100 t treatments for both pulp and beets. The amount of soil inorganic-N present in the 200 t rate treatments for both pulp and beets was significantly greater than that present in 100 t treatments. During the month of July, the inorganic N amount was significantly higher under the fertilized control treatment compared with the unfertilized control, but statistically similar to other by-product treatments. There was no significant difference in soil inorganic N content among treatments during the months of August and September (Table 3).

Table 3: Soil inorganic-N content for the surface 0-18" measured during 2002 sugar beet growing season.

Treatments	Total inorganic N content in soil (0-18") lbs A^{-1}			
	June	July	August	September
Cont.-Fert.	80 A	67 A	14	39
Beets 100t	42 BC	51 AB	12	41
Beets 200t	52 B	63 AB	12	44
Pulp100t	40 BC	41 B	13	40
Pulp 200t	55 B	62 AB	13	45
Cont.-Unfert.	29 C	40 B	16	33
$LSD_{0.05}$	13	23	NS	NS

Residual soil inorganic-N in surface five and a half feet (Fall 2002):

The inorganic-N content in the soil profile is presented in Table 4. Only the 0-6” soil layer showed significant differences among treatments with inorganic-N content significantly higher in the fertilized control treatment compared with all other treatments. There was not much inorganic-N in 6-18” soil layer, but at lower depths it increased under all the treatments. The whole profile (0-66”) data showed that the fertilized control and by-product treatments had similar inorganic-N content. However, only the fertilized control and pulp @ 200 t rate showed significantly higher inorganic-N compared with the unfertilized control treatment (Table 4).

Table 4: Residual soil inorganic-N content in the soil profile after the harvest of sugar beet, fall 2002.

Treatments	Total inorganic N content in soil lbs A^{-1}							
	0-6	6-12	12-18	18-30	30-42	42-54	54-66	0-66
	inches depth							
Cont.-Fert.	29 A	3	2	3	10	12	13	73 A
Beets 100t	16 B	4	2	5	4	15	16	61 AB
Beets 200t	13 B	3	2	7	9	12	15	60 AB
Pulp100t	12 B	2	2	5	7	13	13	53 AB
Pulp 200t	8 B	3	3	6	15	16	15	66 A
Cont.-Unfert.	6 B	2	2	2	8	12	12	44 B
$LSD_{0.05}$	10	NS	NS	NS	NS	NS	NS	20

Nitrate-N in runoff water:

There was no particular trend in nitrate-N concentration of runoff water (Fig. 1). In general, the 200 t rate for both pulp and beets showed higher nitrate-N compared with the 100 t rate treatments. This is probably due to double the amount of organic N applied in 200 t rate treatments compared to 100 t rates. However, runoff nitrate-N concentrations in all treatments were lower than the 10 mg L^{-1} nitrate-N drinking water standard (USEPA, 1973).

Inorganic-N concentration of soil water:

Inorganic-N concentration of soil water obtained at the 18 inch depth using suction tubes is presented in Fig. 2. Similar to nitrate-N in runoff waters, there was no particular trend in inorganic-N data. Early in the season i.e. during the month of July, there was significantly higher inorganic-N present in the fertilized control treatment compared to the other treatments. In general the 200 t rates for both pulp and beets showed higher nitrate-N compared with 100 t rate treatments.

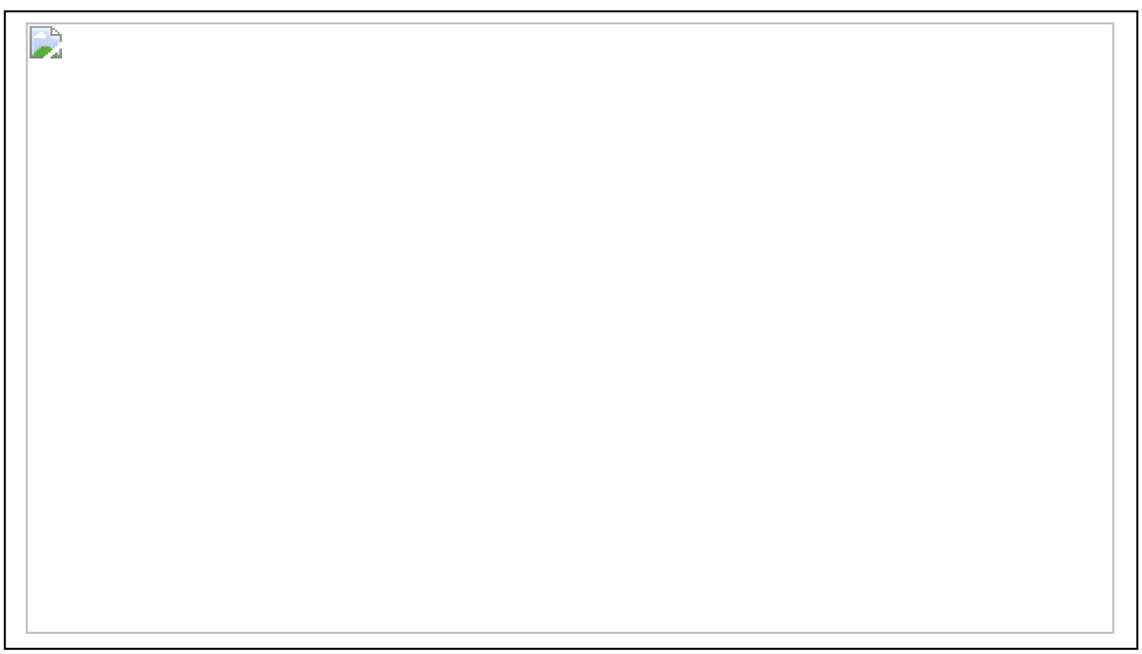

Fig. 1: Nitrate-N concentration of runoff waters during 2002 growing season.

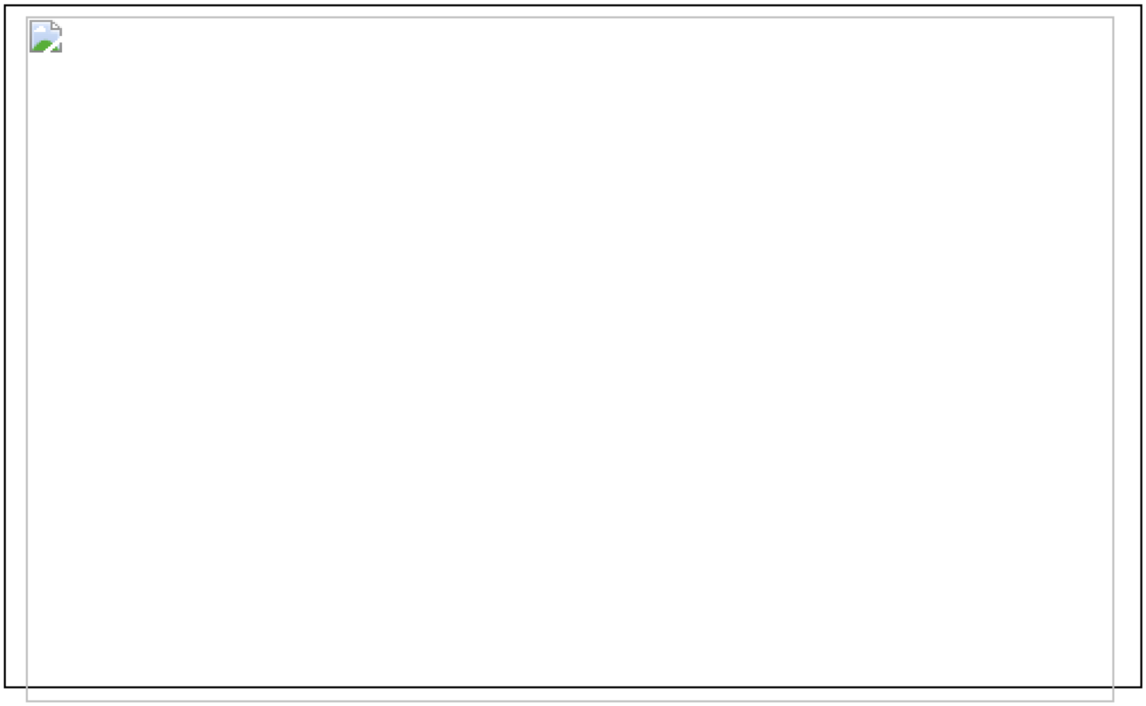

Fig. 2: Inorganic-N concentration in soil water obtained at 18” depth using suction tubes.

CONCLUSIONS

The results of the field studies showed that there were significant residual effects from the previous year application of sugar beet by-products. In contrast to the first year, it seems that the organic N mineralized slowly, making N available in the second year. This led to comparable yields in the fertilized control and by-product treatments as compared to lower yields under unfertilized control treatment. There was some indication that more N became available from the 200 t rate treatments compared to the 100 t rate treatments, which resulted in higher N uptake. Some fine-tuning of N fertilizer may be needed in season with by-product application, especially if the lower 100 t rate is used.

The 200 t rate tended to result in higher root yields and recoverable sucrose, however, the differences in recoverable sucrose were not significant. The concentration of nitrate-N was always less than the 10 mg L^{-1} drinking water limit. The residual inorganic N in soil was also lower with the by-product treatments compared to the fertilized control treatment. This suggests that there might not be any nitrate related environmental problem associated with pulp and beet by-products the second year after application.

Literature cited:

Kumar, K., Rosen, C.J., and Gupta, S.C. 2001. Effect of sugar beet processing by-products on wheat yield, nitrogen mineralization, and run-off water quality. 2001 Sugar beet Research and Extension Reports: 135-140.

Kumar, K., Rosen, C.J. and Gupta, S.C. 2002. Kinetics of nitrogen mineralization in soils amended with sugar beet processing by-products. Communications in Soil Science and Plant Analysis, 33: 3635-3651.

Kumar, K., and Goh, K.M. 2002. Management practices of antecedent leguminous and non-leguminous crop residues in relation to winter wheat yields, nitrogen uptake, soil nitrogen mineralization and simple nitrogen balance. European Journal of Agronomy, 16: 295-308.

USEPA. 1973. Water quality criteria. EPA-R3-73-033. U.S. Govt. Print. Office, Washington DC.

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