APPLICATION OF PAPER MILL RESIDUAL TO POTATO/CORN/SOYBEAN

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Introduction

Land spreading of various types of residual by-products from manufacturing as a means of disposing of these by-products is becoming more widespread throughout Wisconsin. Paper mill residuals, vegetable processing waste and various types of other products are increasingly spread on agricultural land as an alternative to landfill disposal or incineration. These various materials contain nutrients, primarily nitrogen but also various amounts of other primary, secondary and micronutrients. Many of these materials are also noted to be effective in varying degrees as liming agents.

This trial is a continuation of work that was started in 2002. Prior research on this topic conducted by Leslie Cooperband consisted of experiments in the Central Sands area of Wisconsin. Work done by Bowen and Wolkowski, December 1998, on the use of fresh and composted paper mill fiber residuals in potato production at the Rhinelander Experiment Station was also conducted on sandy soil. The soils in Langlade County used for potato production are primarily Antigo Silt Loam. The results of applications of fiber paper mill residual (PMR) to a silt loam soil may produce different results than applications to a sandy soil. In addition the composition of the paper mill residual may vary for each paper mill depending on what components have been blended into their composition. The effect of this material on the pH of the soil and the amounts of various soil nutrients were of concern since an increase in the pH could affect the incidence of potato scab and excessive amounts of any particular nutrient may cause problems. The second area was disease. Would this material affect the incidence of soil or foliar diseases of potatoes that would adversely affect their marketability? This is important since the primary market of potatoes produced in the Langlade County area is for use as seed.

Methods

A randomly replicated trial was set up using paper mill residual from the Wausau-Mosinee Paper Corp. Mill at Brokaw, Wis. Initial soil tests showed average values of; pH 5.4, organic matter 2.4, P-150 ppm and K-217 ppm. The material used was sampled and tested prior to application to determine correct application amounts. Sample results taken at time of application and tested by the Marshfield lab showed the nutrient availability per wet ton for the first year following application to be 3.26# N, 4.33# P_2O_5, .36# K_2O, and .57# sulfur. Average nutrient content over the past 3 years of the material used in these trials is 4.68# N, 5.9# P_2O_5, K_2O, and 1.85# sulfur. The samples have also been tested for dry matter content, ammonia N, total nitrogen, ash content, pH, calcium, magnesium and carbon to nitrogen ratio. The material used in 2004 had a calcium carbonate equivalent of 38.0% and a neutralizing index of 27.9%. Application amounts were calculated based on soil test recommendations indicating a fertilizer need of 150# N, 180# P_2O_5, and 165# K_2O per acre. This amount equaled 38 wet ton per acre (WTA). The trials have consisted of 5 different treatments plus an untreated control replicated four times. This year the entire plot received 500# /acre 3-3-30 with 16 oz Admire /500# /acre at planting.

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tively.

The amount of material added to each 20' by 18' treatment plot was 314# for the 50% rate, 628# for the full rate and 942# for the 150% rate. The material added to each plot was weighed using a platform scale on a trailer at the field site. Soil samples were taken from each plot prior to application and again after harvest. Soil samples were tested for pH, organic matter, phosphorus, potassium, calcium, magnesium, estimated cation exchange capacity, boron, manganese, zinc, sulfur, and sample density.

Nutrients Available per Treatment		Total Nutrients Available (PMR plus com fert)
Treatment 1 – Control		
Starter	15- 15-150	
Added at planting 185# 46-0-0, 356# 0-46-0, 23# 0-0-60	85- 164- 14	
At Hilling 109# 46-0-0	50- 0 - 0	150-179-164
Treatment 2 - 50% rate		
Starter	15- 15-150	
19 WTA PMR, credited at 100%	62- 82- 7	
Added 158# /a 46-0-0, 178# /a 0-46-0, 12# 0-0-60	73- 82 - 7	150-179-164
Treatment 3 - 50% rate		
Starter	15- 15-150	
19 WTA, credited at 50%	31- 41- 3	
Added 226# /a 46-0-0, 268# /a 0-46-0, 17# 0-0-60	104- 123- 11	150-179-164
Total available nutrients at 100% credit		(181-220-177)
Treatment 4 - full rate		
Starter	15- 15-150	
38 WTA, credited at 100%	124-164- 14	
Added 24# 46-0-0	11- 0 - 0	150-179-164
Treatment 5 - full rate		
Starter	15- 15-150	
38 WTA, credited at 50%	62- 82- 7	
Added 158# /a 46-0-0, 178# /a 0-46-0, 12# 0-0-60	73- 82- 7	150-179-164
Total available nutrients at 100% credit		(212-261-183)
Treatment 6 - 150% rate		
Starter	15- 15-150	
57 WTA, credited at 100%	186-246- 21	
Added 0 supplemental fertilizer		201-261-171

May 27 – Paper mill residual material was applied to the plots and incorporated with disc and field cultivator.
June 5 – Snowden potatoes were planted.
June 17 – Applied Dual 2E at 1.6 pints per acre and Linex DF at 1.6# per acre
June 30 – First fungicide application; Bravo Ultrex and Quadris
July 8 – Added supplemental fertilizer to treatments 1, 2, 3, and 5; hilled
October 6 – Harvested plots
October 17 – Graded trials at Hancock
Irrigated – July 22, .5"; July 30, .6"; Aug 15, .7"; Aug 20, .7".

Trial weights were recorded for total yield, culls, undersize and US#1's. The US#1's were size graded and weights were recorded for all potatoes less than 4 ounces, 4-6 ounces, 6-10 ounces, 10-13 ounces, 13-16 ounces and over 16 ounces. Scab ratings, internal defects and trial yields were rated and statistically analyzed by Vaughan James, UW Plant Pathology.

Scab symptom rating and yield.

Trt no.	Scab Rating		Yield						
	Lesion Area Index [1]	Lesion Type Index [2]	TOTAL cwt/A	US#1		Undersize [3]		Culls	
				cwt/A	%	cwt/A	%	cwt/A	%
1	2.1	3.3	346.8	255.9	73.8	13.3	3.8	77.5	22.4
2	2.9	5.6	329.4	274.5	83.5	13.7	4.1	41.2	12.4
3	2.3	4.5	379.6	299.5	79.0	15.5	4.1	64.5	16.9
4	2.5	4.4	332.7	272.3	81.6	11.7	3.5	48.7	14.9
5	3.6	4.6	348.2	280.2	80.6	12.3	3.5	55.7	15.9
6	4.4	6.4	322.2	256.6	79.5	10.1	3.2	55.5	17.3
Pr>F[4]	0.55	0.84	0.41	0.59	0.09	0.56	0.81	0.05	0.10
LSD	NS	NS	NS	NS	6.5*	NS	NS	22.3	6.7*

Specific gravity, and size grades of US#1 size Snowden potatoes

. Trt no	Specific Gravity	Size Grades of US # 1 Potatoes - %						
		< 4 oz.	4-6 oz.	6-10 oz.	10-13 oz.	6-13 oz.	13-16 oz.	> 16 oz.
1	1.098	22.3	26.7	36.4	11.0	47.4	3.6	0.0
2	1.096	26.0	26.6	35.6	8.2	43.8	3.6	0.0
3	1.096	26.3	28.4	34.0	6.7	40.7	4.3	0.3
4	1.096	21.2	28.0	39.3	8.4	47.6	3.1	0.0
5	1.093	23.7	24.2	38.5	8.2	46.7	4.5	0.9
6	1.090	17.6	23.5	38.8	11.4	50.2	8.0	0.7
Pr>F[4]	< 0.01	< 0.01	0.15	0.12	0.29	0.09	0.10	0.65
LSD	0.003	NS	NS	NS	NS	6.5*	3.5*	NS

1 Lesion area index. Lesions were rated on a 5-point scale with: 0 = no lesions; 1 = 1-10% of the surface area of the tuber affected; 2 = 10-25% affected; 3 = 25-50% affected; 4 = 50-75% affected; 5 = > 75% affected. The lesion area index = the sum for all classes of [(the number of tubers in that class x the class number) x 100]/(5 x total number of tubers rated). The maximum value for this index (if all tubers were rated 5) is 100.

2 Lesion type index. Lesions were rated on a 5-point scale as described in the text. The type lesion index was calculated by summing the number in each class x the class number x 100 /(5 x the total number of tubers rated). The maximum value for this index (if all tubers were rated 5) is 100.

3 Undersize indicates potatoes < 1 7/8 inch diam.

4 Analysis of variance was performed on data, and Fisher's protected least significant difference (LSD) was calculated. NS = not significant at $P = 0.10$ (* indicates differences between pairs of treatments were significant at $P = 0.10$, but not at $P = 0.05$).

Tuber internal quality

Trt	% with no internal defects	% with any kind of internal defect	Com-bined Defect Rating	Hollow Heart				Internal Browning				Black Spot/Bruising				
				% with any HH	% with slight HH	% moder-ate HH	% severe HH	% with any IB	% with SLIGHT IB	% MODER-ATE IB	% SEVERE IB	% Bruise Free	% with 1 spot (<1cm)	% with 1 spot (> 1cm)	% with 2-3 spots	% with > 3 spots
1	55.0	45.0	0.8	0.0	0	0	0.0	0.0	0	0.0	0.0	55.0	30.0	2.5	7.5	5.0
2	62.5	37.5	0.7	0.0	0	0	0.0	0.0	0	0.0	0.0	62.5	20.0	2.5	12.5	2.5
3	70.0	30.0	0.4	0.0	0	0	0.0	0.0	0	0.0	0.0	70.0	27.5	0.0	2.5	0.0
4	60.0	40.0	0.6	0.0	0	0	0.0	0.0	0	0.0	0.0	60.0	30.0	0.0	10.0	0.0
5	47.5	52.5	1.0	2.5	0	0	2.5	2.5	0	0.0	2.5	50.0	30.0	5.0	15.0	0.0
6	53.6	46.4	0.8	0.0	0	0	0.0	2.3	0	2.3	0.0	55.9	29.3	2.5	12.3	0.0
Pr>F[2]	0.37	0.37	0.21	0.45	---	---	0.45	0.60	---	0.45	0.45	0.50	0.86	0.65	0.61	0.57
LSD	NS	NS	NS	NS	---	---	NS	NS	---	NS	NS	NS	NS	NS	NS	NS

1 The worst possible rating would be 10. Hollow heart and internal browning categories given values of 1(slight), 2 (moderate), 3 (severe); bruising categories given values of 1 (1 spot<1cm) to 4 (> 3 spots). Combined defect rating = sum of Hollow heart, int. browning and bruising values/10 (the worst defect value a tuber could have if hh=3, ib=3 and bruise=4.

Soil Test Result

pH 2004 Trial

Trtmnt	1	2	3	4	5	6
04-0501	5.25	5.43	5.30	5.30	5.25	5.25
04-1104	5.83	6.38	6.38	7.15	7.25	7.43

2003 Trial

Trtmnt	1	2	3	4	5	6
06/03	4.85	5.08	5.15	5.00	5.05	5.10
11/03	4.83	5.50	5.35	6.05	5.95	6.18
03-0704	5.03	5.38	5.40	5.70	5.70	5.54

OM

Trtmnt	1	2	3	4	5	6
04-0504	2.50	2.60	2.58	2.50	2.48	2.63
04-1104	2.40	2.38	2.48	2.48	2.45	2.70

Trtmnt	1	2	3	4	5	6
06/03	2.15	2.18	2.20	2.18	2.13	2.23
11/03	2.18	2.25	2.30	2.38	2.33	2.40
03-0704	2.20	2.15	2.43	2.30	2.38	2.31

K

Trtmnt	1	2	3	4	5	6
04-0501	172	181	193	166	162	188
04-1104	168	168	172	170	170	196

Trtmnt	1	2	3	4	5	6
06/03	171	165	176	197	196	212
11/03	140	135	119	126	148	153
03-0704	162	163	158	151	175	162

P

Trtmnt	1	2	3	4	5	6
04-0501	118	123	127	123	125	134
04-1104	162	162	170	164	169	169

Trtmnt	1	2	3	4	5	6
06/03	133	145	153	144	150	154
11/03	163	162	163	165	160	162
03-0704	159	151	159	159	160	157

Ca

Trtmnt	1	2	3	4	5	6
04-0501	540	590	560	540	525	570
04-1104	687	765	760	810	855	880

Trtmnt	1	2	3	4	5	6
06/03	505	540	505	515	515	500
11/03	495	550	535	645	545	555
03-0704	550	550	525	595	575	561

Mg

Trtmnt	1	2	3	4	5	6
04-0501	260	120	112	110	110	112
04-1104	103	320	327	510	557	667

(39,000 ppm)

Trtmnt	1	2	3	4	5	6
06/03	83	90	90	90	90	93
11/03	105	248	220	328	315	375
03-0704	115	205	200	282	297	246

Est CEC

Trtmnt	1	2	3	4	5	6
04-0501	5.50	4.25	4.25	4.00	4.00	4.25
04-1104	4.67	7.00	6.75	8.50	9.25	10.25

Trtmnt	1	2	3	4	5	6
06/03	3.75	3.75	3.75	3.75	3.75	3.75
11/03	3.75	5.00	4.50	6.00	5.75	6.50
03-0704	4.25	5.00	5.00	5.50	5.50	5.25

B

Trtmnt	1	2	3	4	5	6
04-0501	0.35	0.3	0.4	0.48	0.43	0.4
04-1104	0.8	0.43	0.43	0.2	0.33	0.33

Trtmnt	1	2	3	4	5	6
06/03	0.23	0.30	0.25	0.28	0.28	0.23
11/03	0.43	0.50	0.58	0.28	0.35	0.38
03-0704	0.18	0.2	0.25	0.25	0.3	0.25

Mn

Trtmnt	1	2	3	4	5	6
04 0504	22.5	22.7	24	21.5	22.7	23.2
04 1104	30	17	18	16	16.5	15.5

Trtmnt	1	2	3	4	5	6
06/03	35.3	33.3	34.8	38.8	35.8	36.0
11/03	35.8	18.8	21.5	17.3	18.0	17.8
03-0704	45.5	30.5	33.5	29.75	31.2	31.25

Zn

Trtmnt	1	2	3	4	5	6
04 0504	2.5	3	2.88	2.7	2.5	2.8
04 1104	2.63	2.9	3.13	3.5	3.8	4.4

Trtmnt	1	2	3	4	5	6
06/03	2.9	3.0	3.0	3.2	3.3	3.3
11/03	3.3	3.3	3.2	3.5	3.5	3.7
11-0704	3.23	3.23	3.1	3.23	3.45	3.25

S(SO4)

Trtmnt	1	2	3	4	5	6
04 0504	5.63	5.15	5.95	5.38	5.85	5.13
04 1104	30.6	31.7	31.5	29.2	19.1	38.2

Trtmnt	1	2	3	4	5	6
06/03	8.0	8.6	7.5	8.2	8.6	8.6
11/03	21.7	29.7	30.3	28.3	31.4	28.3
03-0704	11.8	11.9	12.6	12.33	17.0	13.47

Soil Density

Trtmnt	1	2	3	4	5	6
04-0501	1.02	1.01	1.01	1.03	0.99	1.01
04-1104	1.08	1.08	1.07	1.07	1.06	1.04

Trtmnt	1	2	3	4	5	6
06/03	1.16	1.15	1.15	1.16	1.16	1.15
11/03	1.13	1.12	1.12	1.11	1.12	1.10
03-0704	1.15	1.14	1.15	1.13	1.13	1.14

Results and Summary

There was no noticeable difference in time of emergence or in development of vine growth over the course of the summer. Scab ratings on the harvested potatoes showed no significant difference between treatments in either lesion area index or in the lesion type index. Numerically, treatment 4 showed higher amounts of both lesion area index and lesion type index. In 2002 there was a numerically higher, although not significant scab reading for treatment 3. Yield results also showed no significant difference in total yield, US#1's, undersize or culls between the plots with or without PMR. Undersize potatoes for all treatments ranged from 13.0 cwt to 20.9 cwt and the culls ranged from 15.7 cwt to 20.3 cwt. Specific gravity showed a directly related range from 1.098 for the untreated plot down to 1.090 for treatment #6. This result was nearly identical in both years 2003 and 2004. Analysis of variance showed a difference between pairs of treatment results at P=0.10 but not at P=0.05. In 2002 the readings were also lower for treatment #6 but there was no direct correlation between the higher amounts of PMR and lower readings. In the 2003 trial an analysis of size breakdown of the US #1 potatoes showed no significant difference for all sizes with the exception of the 6-10 oz. size where there was a difference that was significant at the 10% level but not at the 5% level of probability. In the 2004 trial there was a difference in yields of 6-13 ounce and 13-16 ounce potatoes. Checks for tuber internal quality showed no significant difference in amount of hollow heart, internal browning, or for black spot/bruising. Soil sample analysis showed a slight increase in pH and OM for treatments with added PMR. Phosphorous levels showed a sight increase for all treatments including the control. Calcium levels showed a slight decrease to all treatments including the control. The magnesium content of the material applied over the past three years has been relatively high. This has resulted in a temporary sharp increase in soil levels of magnesium which has moderated in later soil samples. This was evident in the results as the magnesium levels in the soil moved from around 90 ppm at planting to a high for treatment 6 of 375 ppm at harvest in 2003. The estimated CEC showed a definite increase as higher rates of PMR were applied. The levels of boron and zinc showed no change. The levels of manganese showed a steady decrease with added amounts of PMR.

Potato Trial Conclusion

The results of this trial were fairly similar to the trial conducted in 2002 and 2003. There were no real significant differences in yield or disease but there were some numerical differences that were similar each year. Yield and internal defect data showed no significant difference for treatments with or without added PMR. The nutrient analysis of the material used in this trial showed nutrient availability for the first year after application for each wet ton to be 3.26# of N, 4.33# of P and .36# of K. With an application of 38 wet ton per acre this material would contain around $60 in available nutrients per acre. Valuing this material as a liming agent, with a neutralizing index of around 20%, an application of 38 tons per acre could possibly replace 5 tons of aglime per acre for an additional value of around $125 /acre. With no significant differences in yields it appears that the nutrients in this material are able to be utilized by potatoes. The pH levels showed a significant increase for samples taken six months after application. Samples taken 18 months after application showed that the large amount of increase was temporary as pH levels then were shown to have declined back closer to original levels. Samples taken 30 months after application show that pH levels had leveled off at a point for the full application rates of around 5.7 with a pH of 5.2 at time of application. Trial results indicate that with accurate analysis and accurate application rates, the use of this material for potato production should be an acceptable practice.

Soybean Production and Long-Term Soil Effects

In 2003 soybeans were planted on the area used for the PMR trial in 2002. Treatments applied in 2002 followed the same sequence as was used in 2003.

Treatment 1 – Control
Treatment 2 - 50% rate, (10.7 WTA), plus 0 added N
Treatment 3 - 50% rate plus 62# supplemental N
Treatment 4 - full rate of 21.4 WTA plus 0 added N
Treatment 5 - full rate of 21.4 WTA plus 62# added N
Treatment 6 - 150% rate, (32.1 WTA), plus 0 added N

2003 was extremely dry in Langlade County for the majority of the summer and the soybeans received no supplemental water. Treatment number 3 and treatment number 5 received 62# of supplemental N in 2002. They were planted with a grain drill on May 24 with Pioneer 90B74, Round-Up Ready, soybeans. Soybeans were cut on October 21 with a John Deere sickle mower. The cut beans were bagged and taken to Arlington where they were threshed out using a small plot combine. Vine height was measured on August 20, 2003. Soil samples were taken again on November 3, 2003 to check for long-term changes in soil nutrient levels.

Paper Mill Residual Effect on Soybean yield and Grain Composition

Trt#	Paper mill residue	Nitrogen lb/a (2002)	Grain Yield	Grain Moist.	Height	Total plant weight	Test weight	Seed composition Protein	Seed composition Oil	Seed composition Fiber
	tons/a		bu/a	%	in	lb/140 sq ft	lb/bu		%	
1	0	0	18.4	12.0	20.8	9.2	57.8	35.7	19.1	5.1
2	10.7	0	19.2	11.6	23.1	9.9	57.9	35.6	18.7	5.1
3	10.7	62	19.2	13.2	22.9	9.5	57.9	35.9	18.8	5.1
4	21.4	0	19.7	11.8	22.8	10.1	58.4	37.3	17.9	5.0
5	21.4	62	20.9	12.4	23.0	10.5	56.0	37.9	17.2	4.9
6	32.1	0	23.5	11.9	24.4	11.3	56.8	38.3	16.9	4.9
Means			20.1	12.1	22.8	10.1	57.5	36.8	18.1	5.0
Probability %			>50	19.4	46.3	>50	38.0	4.4	1.2	15.7
LSD 10%			NS	NS	NS	NS	NS	0.7	0.4	NS

Soybean Results and Summary

Yield results showed higher yields, greater plant height and greater amounts of dry matter with the higher amounts of PMR. There was also a significant increase in the protein and oil content in the soybeans harvested from the plots with the added PMR. Soil test results showed no real long-term change in soil nutrient levels with the exception of magnesium, which showed an increase in 11/02, and a slightly lower reading in 11/03. The added organic matter may have helped to retain soil moisture or there may be other factors similar to those seen when applying dairy manure that affect yield but are hard to pinpoint. This trial indicates that soybeans planted in 2003 on these plots benefited favorably from the addition of PMR in 2002.

Corn Trial Using PMR

In 2003, a trial was conducted using the same treatment protocol consisting of six treatments replicated four times that has been used for the potato trials.

Treatments for PMR Corn 2003
6 row(18') plots 20' long

	Starter (100# 19-19-19)			PMR			At planting N	At planting P2O5	At planting K2O	Total N	Total P2O5	Total K2O
treatment 1 Control	19	19	19	0	0	0	121	0	46	140	19	65
Treatment 2, 13.25 tn PMR 50% rate, 100% credit	19	19	19	62	82	7	61	0	45	142	101	71
pounds PMR/plot				219								
treatment 3, 13.25 tn PMR 50% rate, 50% credit	19	19	19	30	64	0	91	0	46	140	83	65
pounds PMR/plot				219								
treatment 4, 26.5 tn PMR 100% rate 100% credit	19	19	19	120	249	2	0	0	44	139	268	65
pounds PMR/plot				438								
treatment 5, 26.5 tn PMR 100% rate, 50% credit	19	19	19	60	124	1	61	0	45	140	143	65

pounds PMR/plot				438								
treatment 6, 39.75 tn PMR	19	19	19	180	249	4	0	0	42	199	268	65
150% rate, 100% credit												
pounds PMR/plot				657								

Shell corn yield results harvest 11-13-03

Sample #	wt(gms)	wt (lbs)	% moist	Test wt	#DM	Wt # @ 15.5% moist	wt/a @ 15.50%	bu/a @56#/b
1	4544.3	10.02	37.33	41.25	6.28	7.43	5395	96.3
2	4202.7	9.27	34.48	40.53	6.05	7.16	5200	92.9
3	4273.4	9.42	33.78	40.25	6.24	7.39	5364	95.8
4	4180.8	9.22	34.13	40.85	6.08	7.19	5221	93.2
5	4828.3	10.64	37.15	40.50	6.73	7.97	5784	103.3
6	4540.1	10.01	35.23	41.65	6.49	7.68	5577	99.6

Corn Silage Data

Sample No						Forage Analysis					
1	Net t/a	wet sample	dry sample	%DM*	DM tn/a	% DM**	%Moist	Cd Prot	ADF	NDF	NFC
2	16.72	298.39	95.70	32.07	5.36	32.23	67.77	8.86	23.52	42.71	42.24
3	16.48	276.42	89.84	32.50	5.36	32.74	67.22	8.69	24.37	45.06	40.47
4	17.61	247.20	79.33	32.09	5.65	32.91	67.10	9.20	23.65	42.94	41.86
5	16.34	290.40	94.72	32.62	5.33	31.04	68.97	9.14	24.61	44.86	40.10
6	17.33	251.56	81.22	32.29	5.60	31.56	68.44	9.09	24.38	44.44	40.26
	17.57	294.03	95.47	32.47	5.70	31.60	68.40	8.96	23.40	43.83	41.46

Sample No	Starch	Non-stch NFC	Fat	TDN	milk /tn DM	Mlk/acre	P	Ca	K	Mg	Ash
1	31.29	10.95	3.20	74.34	3795	20347	0.22	0.29	1.04	0.20	4.30
2	30.13	10.33	3.20	73.84	3764	20161	0.21	0.29	1.04	0.20	3.89
3	30.45	11.42	3.20	75.06	3866	21842	0.22	0.31	1.08	0.21	4.12
4	28.13	11.98	3.20	74.49	3820	20353	0.22	0.32	1.06	0.22	4.00
5	29.53	10.73	3.20	74.40	3816	21356	0.22	0.31	1.14	0.21	4.32
6	31.15	10.30	3.20	74.95	3852	21973	0.22	0.30	1.03	0.20	3.85

Corn Trial Summary

Shell corn samples showed a slightly lower yield for treatments 2 and 3 when compared to the control treatment 1. In the silage analysis there was no difference between silage yields when comparing treatments 1, 2, and 4. In the shell corn analysis there was an increase in yield for treatment 3 over treatment 2 and for treatment 5 over treatment 4 as well as an increase in yield for treatment 6 over the control. This may suggest that the fertilizer level of 140-20-65 should have been higher. Corn silage yields show no difference between treatments 1, 2, and 4. Here again we see an increase in yield for treatments 3, 5, and also 6. Milk per acre also shows no difference for treatments 1, 2, and 4 but again we see an increase for treatments 3, 5, and also 6. The use of PMR especially in a corn-hay rotation would appear to be a positive step toward utilizing a by-product and appears to have no negative effects on corn or soybean production.

Metals Content Information

The following information has been furnished by STS Consultants, LTD. Green Bay, WI.
Steve Shimek, Associate Scientist, 1-920-468-1978; e-mail: shimek@stsconsultants.com

Metals Content Comparison Item	Concentration in Parts per Million							
	Cadmium	Lead	Arsenic	Chromium	Mercury	Nickel	Copper	Zinc
Wausau-Mosinee, Brokaw Mill [1]	0.45	No Detect	0.45	8.29	No Detect	4.98	17.8	45.7
Local Topsoil [2]	0.1	5.6	2.4	11.9	0.02	6	4.7	24
Average U.S. Topsoil [3]	0.27	12	No Detect	No Detect	No Detect	24	30	57
Commercial Fertilizer (N-P-K) [4]	5.3	1.6	<0.1	70	<0.1	11	4.6	60
Fresh and Rotted Manure [5]	No Detect	125	No Detect	12	No Detect	No Detect	6.7	75
Wood Ash [6]	<1.5	125	48	34	0.4	23	116	424
Ace Hardware Vegetable Food [7]	1.8	5.3	2.9	No Detect	0.5	11	No Detect	368
Nu Life Trace Elements [8]	86.8	2491	29.2	No Detect	2491	515	No Detect	68,150

Source for item 1 - STS Consultants

1) STS Consultants, Table 5 Sludge Analytical Summary Wausau -Mosinee Paper Mill Corp, December 2000.

2) STS Consultants, Topsoil sample from the Town of Kronenwetter, Marathon County.

Data from the following sources referenced in U.S.-EPA Publication EPA 747-R-98-003, 1999

3) Holmgren, 1993
4) International Mineral Corp., 1997
5) Arora, et al., 1975
6) Washington Dept. of Ecology,1997
7) Seattle Times, 1998

Wisconsin Metal and Dioxin Loading Limits and Site Life Estimates [1]

Parameter	Cumulative Limit (Pounds/Acre)	Wausau-Mosinee Paper Corp Brokaw WI	
		(Pounds/Dry Ton)	Years of Site Life
Cadmium	4.5	0.0009	500
Copper	110	0.036	305
Lead	445	<0.0044	>1011
Nickel	45	0.010	450
Zinc	225	0.091	247
TDE [2]	1.20 (ppt)		>706

Note: **1)** Limits based on NR 214 and WDNR guidance. Table values assume minimum cation exchange capacity, and a crop nitrogen requirement met with 10 dry tons per acre.
The ppt = parts per trillion
2) TDE is total dioxin equivalency, which is the sum of 2,3,7,8-TCDD + (0.1x 2,3,7,8-TCDF)
Prepared by STS Consultants, Ltd. January 2003.
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