Slurry Enriched Micro-Site Seeding of Biosuppressive Cover Crops for Sugar Beet Production

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Improving pest management strategies, soil quality, and stand establishment are top priorities of the sugar beet industry. The development of crop management alternatives that reduce tillage intensity and encourage the use of cover crops will improve soil quality by increasing soil organic matter. Manure has been shown to improve soil quality by increasing soil organic matter and hydraulic conductivity, and by decreasing soil bulk density. A lower bulk density allows more extensive root growth and a favorable pore size distribution which increases water infiltration, water holding capacity and soil aeration.

Cover crops are generally grown for soil conservation, but cover crops also improve soil quality by adding organic matter and increasing soil biological activity. In Michigan, growers often use winter cereals as cover crops to protect the soil from wind erosion, but stand establishment costs and the additional management requirements have limited their widespread use. Cover crops in the Brassica (mustard) family may offer benefits beyond soil conservation in sugar beet rotations. Forage radish crops have been used to alleviate compaction in coastal plain soils in Maryland. In Michigan, sugar beet yields increased two tons/acre following an oil seed radish cover crop (Poindexter and Van Sickle, 2004). And, oil seed radish has been shown to suppress the sugar beet cyst nematode. The incorporation of oriental mustard (*Brassica juncea* L., variety Pacific Gold) in the spring before planting potatoes suppressed *Rhizoctonia solani* by 73%, and the cover was highly suppressive of fungal activity by *Pythium ultimum,* and *Fusarium solani* (Snapp, 2004). There is a need to evaluate the potential for disease suppression in sugar beet from Brassica cover crops.

Objectives

The objectives of this work were to: 1) Evaluate a new and resource efficient seeding method - *slurry enriched micro-site seeding* - for establishing bio-suppressive cover crops in small grain stubble, and 2) quantify effects of treated soil/cover crop combinations on emergence and the frequency of *Rhizoctonia* in sugar beets.

Methods and Materials

Cover crop establishment

In 2005, a replicated trial comparing oil seed radish (*Colonel*, 16.8 kg ha PLS) and oriental mustard variety (*Pacific Gold,* 11.2 kg ha PLS) was established following wheat (August 8, 2005) in a Capac sandy loam soil at the University Farm in East Lansing. Three seedbed tillage were compared: 1) two passes with a Kongskilde Triple-K combination tillage tool in untilled wheat stubble at a depth of 7.5 cm, 2) direct-drilling into untilled wheat stubble with a Great Plains no-till drill (disk openers on 19 cm centers), and 3) slurry-enriched micro-site seeding in untilled wheat stubble. The plots were arranged in a randomized complete block with six treatments and four replications. The seedings were made on August 8 and harvested on October 20, 2005.

The slurry seeding treatments were established using a commercially available slurry tanker (3000 gallon capacity) equipped with a rear-mounted Aer-Way SSD low-disturbance soil aeration and slurry distribution system. Swine manure (1.7 % dry matter) was applied at 56,100

L ha^{-1}. The soil aerator gang angle was set at 10° for maximum soil disturbance. The seed was placed in the spreader tank where bypass flow provided tank agitation and seed mixing. Drop tubes delivered the seed-laden slurry from the chopper/distributor to the loosened soil behind each set of rolling tines. The 56,100 L ha^{-1} application of swine slurry provided 204 kg ha^{-1} total N (172 kg ha^{-1} as NH_4-N), 76 kg ha^{-1} P as P_2O_5, and 123 kg ha^{-1} K as K_2O. Because commercial fertilizer is not often used for cover crop establishment, no fertilizer was applied to the non-manure plots.

Sugarbeet seed emergence--greenhouse

The brassica cover crops were incorporated with tillage in late October, 2005. Two weeks after incorporation, representative soil samples from each manure/cover crop treatment were collected from the surface to six-inch soil layer. Untreated samples (experimental control) were gathered from adjacent areas at the north and south perimeters of the field site. The soil was placed in cylindrical PVC containers (6.4 cm x 2.54 cm) and compacted to an air-dry bulk density of 1.16 g/cc. Eight sugar beet seeds (EL0204; uncoated, untreated) were planted at a depth of 8 mm in each container. Three replications were evaluated for each of the four field replications of each the four field treatments (48 containers). Additionally, six untreated control containers were evaluated. The containers were incubated at 29º C and 90% RH for 28 days and seed emergence was recorded daily.

Sugar beet yield and quality

Sugar beets were planted on May 15, 2006. The beets were hand-harvested from 13.3 m of row at the center of each plot on November 1. Each beet was visually inspected for the presence of *Rhizoctonia*. Sub-samples were evaluated for percent sugar and clear juice purity by Michigan Sugar Company.

RESULTS

Cover crop biomass

The above-ground plant mass, root mass, total biomass and plant stand density from the six cover crop treatments are listed in Table 1. There were no significant differences in top growth biomass between tillage and seeding methods. There were, however, significant effects on plant stand density. The direct-drilled OSR and OM plant stands were significantly greater than the slurry-seeded OSR and OM plant densities ($p \leq 0.01$).

Table 1. 2005 cover crop biomass yield and 2006 sugar beet yield, quality and frequency of *Rhizoctonia*.

2005 Cover crop				2006 Sugar beet crop					
Cover Crop	Seeding method	Aboveground biomass, kg ha^{-1} [a]	Root biomass, kg ha^{-1}	Beets, kg ha^{-1}	*Rhizoc* per 300m	Sugar, %	Purity, %	RWS Kg Mg^{-1}	RWS Kg ha^{-1}
OSR	Till-drill	4376 a	741 a	26.5 a	91 ab	17.1 a	93.8 a	123 a	7292 a
OM	Till-drill	4054 a		26.7 a	29 b	17.0 a	93.5 a	122 a	7267 a
OSR	Slurry	3876 a	947 a	30.9 a	62 ab	16.0 a	92.8 a	112 a	7792 a
OM	Slurry	4715 a		27.3 a	131 ab	16.9 a	93.7 a	121 a	7353 a
OSR	No-till	4724 a	598 a	26.3 a	203 a	16.6 a	93.7 a	117 a	6999 a
OM	No-till	4081 a		28.3 a	96 ab	16.9 a	94.2 a	122 a	6919 a

[a] abc letters within columns indicate values not significantly different by Tukey's HSD procedure ($p \leq 0.05$).

Sugar beet seed emergence--greenhouse

There was a clear difference in the rate and final percentage of emergence between the treated and untreated soils (Figs. 1 and 2). Emergence occurred more rapidly and continued for a few days longer in the treated soils. There was no increase in the rate of emergence in the control soil after day twelve. Emergence continued at a nearly constant rate in the treated soil until day 15. Final emergence was about 50% in each of the treated soils, 33% in the untreated soil.

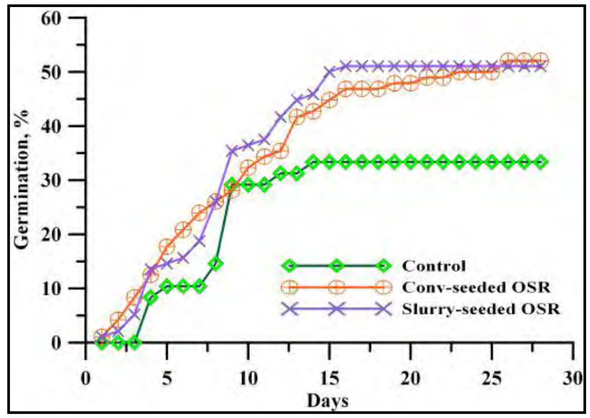

Figure 1. Sugar beet germination and emergence in soil previously treated with an oil seed radish cover crop with and without swine manure slurry.

Sugar beet yield and quality

The average beet stand was 133 beets per 30.5 m (100 ft). There was no significant difference in plant stand due to cover crop tillage and stand establishment method ($p = 0.86$). The occurrence of *Rhizoctonia* in the sugar beet crop following the no-till seeding of OM and OSR was significantly greater than in the tilled-and-drilled seedings ($p = 0.07$). *Rhizoctonia* was significantly greater in the no-till OSR than in the tilled-and-drilled OM ($p = 0.045$; Table 1).

There were no significant differences in sugar beet yield, percent sugar, percent clear juice purity, raw white sugar per ton (RWST), or raw white sugar (RWSA) due to the previous cover crop and seeding method ($p \leq 0.05$).

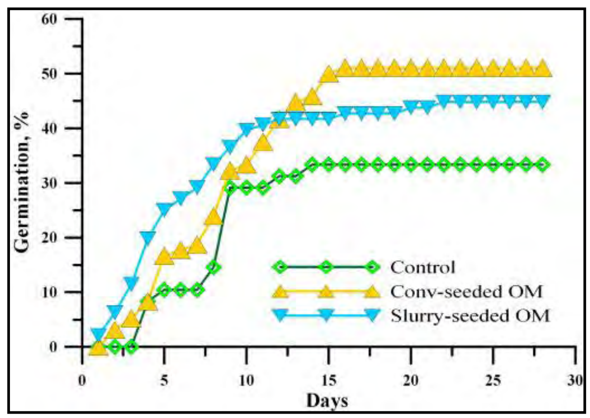

Figure 2. Sugar beet germination and emergence in soil treated with an oil seed radish cover crop, with and without swine manure slurry.

On-farm results, 2006-2007

Oil seed radish (var. Colonel, 22.4 kg ha^{-1}) and oriental mustard (var. Pacific Gold, 13.4 kg ha^{-1}) were sown in untilled wheat stubble on a sandy clay loam on 8 August 2006 and 2007 at the Lakke-Ewald farm in Unionville. Two seeding methods were used: 1) direct-drilling with a Deere 750 no-till drill (6.3 m width, 19 cm spacing), and 2) slurry seeding with aeration tillage and seed-laden dairy manure (10° gang angle, 93,500 L ha^{-1}). The plots (610 m x 6.3 m in 2006, 305 m x 6.3 m in 2007) were arranged in a randomized complete block with four replications.

The August 2006 manure application contained 340 kg ha^{-1} total nitrogen; 186 kg ha^{-1} was readily available as ammonium N and 155 kg ha^{-1} was bound in the organic fraction. The estimated organic N available in the first year was 46 kg ha^{-1}. In 2007, the manure contained 321 kg ha^{-1} total N of which 196 kg ha^{-1} was plant available and 125 kg ha^{-1} was in the organic fraction. The estimated fraction of the organic N available in the first growing season was 31 kg ha^{-1}. Fifty-six kg ha^{-1} N as 28% was applied to the direct-drilled plots each year before planting. At planting, 34 kg ha^{-1} N as 28% was applied to all plots, and 78 kg ha^{-1} N as 28% was applied as a side dress treatment to all plots that did not receive manure.

In 2006, the direct-drilled OM stand (123 plants m^{-2}) was significantly greater than the manure slurry-seeded OM stand (57 plant m^{-2}; $p \leq 0.05$), but there was no difference between the direct-drilled OSR stand (69 plants m^{-2}) and the manure slurry-seeded OSR stand (46 plants m^{-2}; $p \leq 0.05$; Table 1). There were significant effects on surface biomass due to both seeding method ($p < 0.01$; manure slurry seeding was greater than direct drilling) and crop sown ($p < 0.01$; OM was greater than OSR). The manure slurry-seeded OSR surface biomass (3.5 Mg ha^{-1}) was significantly greater than the direct-drilled OSR ($p = 0.01$; 2.2 Mg ha^{-1}), and the manure slurry-seeded OM (2.06 ton ac^{-1}) was significantly greater than the direct-drilled OM (3.5 Mg ha^{-1}).

Table 2. Fall 2006 cover crop biomass, spring 2007 sugar beet crop nematode population and recommended side-dress nitrogen.

	Fall 2006 Biomass *				Beets, May 2007			
Seeding Method	Surface Mg ha^{-1}	Root Mg ha^{-1}	Total Mg ha^{-1}	Plants per m^{-2}	Nematode** concentration	Recommended N, kg ha^{-1}	Rhizoc/300 m East Field	Rhizoc/300 m West Field
Check--no cover crop, no tillage	---	---	---	---	399 ab	5 a	41 ab	34 ab
No cover crop, slurry	---	---	---	---	495 ab	69 b	25 ab	17 ab
Oil seed radish, slurry seed	3.51 b	1.25 b	4.77 b	46.3 a	200 ab	46 b	43 ab	6 a
Oil seed radish, drilled	2.20 a	1.34 b	3.59 a	68.9 a	49 a	10 a	28 ab	57 b
Oriental mustard, slurry seed	4.61 c	0.63 a	5.24 b	57.0 a	584 b	50 b	20 ab	12ab
Oriental mustard, drilled	3.49 b	0.85 a	4.16 ab	122.7 b	483 ab	16 a	21 ab	7 ab

* abc letters within the same column represent significant differences ($p \leq 0.10$) by Tukey's HSD procedure. Analysis of the SBCN and Rhizoctonia data was by the nonparametric Friedman median aligned test ($p \leq 0.10$).
** Risk ratings based on SBCN eggs plus J2's per 400 cm^{-3} of soil: no risk = 0; low = 1-1,500; moderate = 1001-10,000; high = >10,000.

The sugar beet cyst nematode concentration was evaluated in soil samples collected on May 31, 2007. All samples were considered 'low' or 'no' risk. The SBCN concentration following the drilled OSR was significantly less than the slurry seeded OM ($p = 0.042$), but there was no significant difference between the other treatments. Although the field was rated low risk based on the nematode screening, the average beet yield of the resistant variety was 5.9 Mg ha^{-1} greater than the susceptible variety (Table 2). There was no significant difference in clear juice purity, % sugar or RWST between treatments in the east and west sides of the field. Although the resistant variety averaged nearly one percentage unit lower in sugar and ten pounds per acre lower in RWST, it averaged 1232 kg ha^{-1} greater in RWSA than the susceptible variety. The direct drilled OM yielded significantly greater recoverable sugar than all treatments except the drilled OSR.

Table 3. Sugar beet harvest data, 2007.

	East Field 2007, Nematode Resistant Variety *					**West Field 2007, Nematode Susceptible Variety**				
Seeding Method	Mg ha^{-1}	CJP, %	% Sugar	RWS Kg Mg^{-1}	RWS Kg ha^{-1}	Mg ha^{-1}	CJP, %	% Sugar	RWS Kg Mg^{-1}	RWS Kg ha^{-1}
Check, no cover, no tillage	33.2 abc	95.3 a	17.4 a	129 a	8567 bc	27.0 a	95.4 a	18.6 a	135 a	7286 a
No cover crop, manure	30.5 a	95.3 a	17.2 a	126 a	7757 c	23.9 a	96.1 a	18.2 a	133 a	6348 a
Oil seed radish, slurry seed	31.4 ab	95.0 a	17.2 a	126 a	7963 bc	27.3 a	94.3 a	18.4 a	133 a	7607 a
Oil seed radish, direct drill	33.8 abc	95.8 a	17.0 a	131 a	8856 ab	27.7 a	95.9 a	18.4 a	136 a	7483 a
Oriental mustard, slurry seed	31.0 ab	95.5 a	17.4 a	126 a	7814 bc	28.6 a	95.4 a	17.6 a	129 a	7078 a
Oriental mustard, direct drill	37.4 c	95.6 a	17.5 a	130 a	9880 a	27.3 a	95.9 a	18.1 a	129 a	7315 a
Treatment avg.	32.8	95.4	17.3	128	8439	26.9	95.5	18.2	134	7186

*abc letters within the same column represent significant differences by Tukey's HSD procedure ($p \leq 0.10$).

In 2007 the direct-drilled OM stand (222 east; 190 west plants m^{-2}) was significantly greater than the slurry-seeded OM stand ($p \leq 0.05$), but there was no difference between the direct-drilled OSR and the manure slurry-seeded OSR ($p \leq 0.05$; Table 3). The manure slurry-seeded OSR surface biomass (4.66 Mg ha^{-1}) was not significantly different from the direct-drilled OSR (5.33 Mg ha^{-1}), but the manure slurry-seeded OM (4.75 Mg ha^{-1}) was significantly greater than the direct-drilled OM (3.47 Mg ha^{-1}). There was no difference in root biomass between the slurry-seeded and direct-drilled oil seed radish.

Table 4. Fall 2007 cover crop biomass.

Seeding Method	2007 East Field Cover Crops			2007 West Field Cover Crops		
	Surface Mg ha^{-1}	Root Mg ha^{-1}	Plants/m^2	Surface Mg ha^{-1}	Root Mg ha^{-1}	Plants/m^2
Check, no cover, no tillage	1.88 d	---	---	1.77 c	---	
No cover crop, manure	2.06 d	---	---	1.52 c	---	
Oil seed radish, slurry seed	4.66 ab	1.14 a	55 b	5.82 a	1.37 a	49 b
Oil seed radish, direct drill	5.33 a	1.21 a	95 b	5.58 a	1.08 a	107 b
Oriental mustard, slurry seed	4.75 a	---	93 b	5.29 a	---	80 b
Oriental mustard, direct drill	3.47 c	---	222 a	4.19 b	---	190 a

* abc letters within the same column represent significant differences by Tukey's HSD procedure ($p \leq 0.10$).

CONCLUSIONS

The results of the 2005 biomass yield and stand density measurements indicated that the manure slurry enriched micro-site seeding process can provide yields equivalent to conventional seeding methods. Based on two years of cover crop data and one year of sugar beet data at the Ewald farm in Unionville in 2006 and 2007:

- Slurry seeded plant populations were 40 to 67% of the direct drilled crops, but total biomass production was equal to or greater than direct drilling.
- Volatile nitrogen losses from the manure application were enhanced by warm weather when the cover crops were seeded, but vigorous growth of the cover crops in the fall indicated considerable manure N scavenging and uptake.
- Most of the plant available nitrogen from the manure application was lost by volatilization or became unavailable through plant uptake, leaching or other means. The N release from the organic manure fraction and the incorporated cover crop did not meet the N requirements of the sugar beet crop.
- Although in most cases there was no statistically significant difference in yield (Mg ha^{-1} or RWS-ha^{-1}) between manured and non-manured treatments, a pre-side dress nitrogen test indicated significantly more available N in the treatments which had received no manure. The treatments which had received manure appeared N deficient throughout the growing season.
- Neither seeding method nor seed variety had a clear effect on the incidence of Rhizoctonia in the sugar beet crop. There was no significant difference between treatments in the west side (nematode susceptible variety) of the field. On the east side of the field (nematode resistant) only the slurry-seeded OSR had significantly less Rhizoctonia than the drilled OSR. There were no significant differences between the other treatments.
- Even though soil samples processed on May 31 2007 indicated a low risk of an adverse economic impact due to damage from sugar beet cyst nematode, the SBCN resistant variety averaged 1232 kg RWS-ha^{-1} more than the susceptible variety, and there was greater variability between treatments with the susceptible variety. The SBCN concentration was significantly less following the drilled OSR.

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