Cover It Up!

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Introduction

Cover crops were commonly used before the development of manufactured fertilizers for many commodity crops as they help improve soil structure and productivity. Due to high fuel and input costs, a cover crop resurgence is occurring.

Cover crops can serve many beneficial purposes in production systems. These include nitrogen management, erosion control, improving soil quality, weed suppression, and insect management.

Nitrogen management: Legume cover crops, such as red or white clover, produce organic nitrogen. Nitrogen from the residues of these covers acts as a slow-release fertilizer, particularly when the green and vegetative biomass is incorporated.

Erosion control: It is always better to keep plant roots in any field. Cover crops and their root systems reduce wind and soil erosion, but also reduce weed populations, thus reducing weed seed pools, which will improve weed control over time.

Soil quality: Cover crops enhance soil structure and increase soil microorganism activity. They reduce soil compaction while increasing water percolation and retention. They also improve soil organic matter, which is a long process.

Weed suppression: As previously mentioned, cover crops can play an important role in managing weeds. They shade and interfere with weed germination and establishment. Cereal rye, for example, produces allelochemicals, naturally produced compounds that can suppress weeds. Don't forget that cover crops can become weeds themselves. Hairy vetch has become a weed in some fields in Michigan and many farmers I have talked to do not recommend planting it, especially when farmers have small grains in their rotation.

Insect management: This is an area that needs much more research, but scientists do know that cover crops can have an important role in biological insect control. Some insects such as cutworms and slugs can increase populations in cover crop residues.

Before planting, growers need to think about cover crop seed, varieties, and planting times. Seed supply for cover crops can sometimes be a challenge. Contact your county Extension educator for local sources.

New Ways to Use Cover Crops

At Michigan State University we are evaluating ways to work with dairy and livestock farmers who face economic and environmental challenges. Cropping systems that reduce tillage intensity and increase the use of cover crops improve soil quality and protect the environment in many ways. However, environmentally sensitive manure applications continue to be a challenge in no-till cropping systems.

There is a need for cropping and manure management options that stabilize soil and prevent overland flow of sediment, nutrients and contaminants. Such options will retain manure in the root zone for nutrient cycling and remediation of pathogens. Cover crops have not been used widely in livestock-based cropping systems because establishment costs, competition, and labor for added management needs have discouraged their use. Because cover crops are an effective barrier to overland flow, erosion, sedimentation, and manure contamination of waterways, interest in the use of cover crops is increasing.

Manure Slurry-Enriched Seeding

A new land application process — manure slurry-enriched seeding — has been in development at Michigan State University since 2003 (Harrigan et al., 2006). Manure slurry-enriched seeding combines low-disturbance aeration tillage, manure application, and the seeding of cover crops in one efficient operation. Low-disturbance aeration tillage creates an absorptive surface in untilled ground that inhibits overland flow by fracturing the soil, increasing surface roughness, improving infiltration, and conserving crop residues. Cover crop seed mixed with the manure slurry in the spreader tank is placed in bands over the fractured and loosened soil behind each set of aeration tines. The nutrient-rich, seed-laden slurry quickly infiltrates the soil matrix, thereby minimizing volatile nitrogen losses. The loose, absorptive soil surface prevents soil erosion and phosphorus runoff. A cover crop soon emerges, thereby capturing nutrients and forming a vegetative barrier to overland flow. The aerated soil is generally suitable for no-till planting with no additional seedbed tillage.

Objectives

Recent work at Michigan State University has shown that excellent stands of oil seed radish, oriental mustard and other cover crops can be established in untilled ground with manure slurry-enriched seeding which combines seeding, manure application, and aeration tillage in one sustainable and efficient operation. The overall goal of this work was to develop an environmentally sensitive option for manure land application in no-till and diverse cropping systems. Specific objectives were to: (1) evaluate biomass yields of various cover crops established with the new manure slurry-enriched seeding and no-till drill seeding methods, and (2) evaluate the plant population (plants m^{-2}) obtained with slurry seeding and no-till drill seeding methods.

Methods and Materials

A range of cover crop species were sown in wheat stubble at various Michigan locations from 2004-2006. The slurry seeding was done with a commercially available slurry tanker (3,000 gal.) equipped with a rear-mounted rolling-tine aerator (12 foot Aer-Way, Holland Equipment Ltd. Norwich, Ontario, Canada) and a SSD (sub-surface deposition) slurry distribution system. The rolling-tine aerator was ground-driven with sets of four 8-inch tines mounted helically on a rotating shaft with 17.5-inch spacing between each set of tines. The tines were angled slightly on the shaft to provide lateral movement and loosening of the soil. The angle of the rotating shaft was adjustable in 2.5º increments from 0º to 10º from perpendicular relative to the direction of travel. The 0º gang angle provided little soil disturbance while the 10º gang angle provided the most soil loosening. No additional seedbed tillage or soil firming was done.

The slurry-seeding process involved mixing cover crop seed in the slurry tank and passing the seed-laden slurry through a hydraulically driven, rotating chopper/distributor (300 rpm) with radially configured outlets, and then through drop tubes to the fractured and loosened soil behind each set of rolling tines (Figure 1). The throughput of the PTO-driven centrifugal pump on the slurry tank was about 1,585 gal./min., but only 423 gal. was needed to apply agronomic rates of 30,500 to 36,600 gal./A through the 12foot applicator. The excess pump capacity provided bypass flow for seed mixing and distribution. Slurry rate calibration was based on tractor engine RPM, travel speed, machine width, and slurry flow rate. The flow rate was monitored with an electromagnetic flow meter (5-inch diameter; Danfoss, Danfoss Inc., Milwaukee, WI) mounted on the SSD. A 112-PTO-kW tractor or larger was needed to draw the slurry tank and aeration tool at 3 mph.

Biosuppressive Cover Crops — Oil Seed Radish and Oriental Mustard

East Lansing, 2004

Replicated plots (12 × 60 ft.) were established in a randomized complete block with four replications in a Capac fine sandy loam. Two oilseed radish (Raphanus sativus L.) varieties: (1) Common (Com-OSR), and (2) Colonel (Col-OSR), 18 lbs./A pure live seed (PLS), and one oriental mustard (Brassica juncea L) variety (Pacific Gold [OM], 12 lbs./A PLS) were sown in untilled wheat stubble on 13 August. Each crop was sown with a Great Plains no-till drill (10-foot width, 7.5-inch opener spacing) and with the manure slurry seeding process. The aerator gang angle was set at 10° for maximum soil fracturing. The seed-laden swine slurry was applied at 56,100 L ha^{-1}. Aboveground and root biomass and plant stand (plants m^{-2}) were evaluated on 13 October, 2004.

East Lansing, 2005

Oil seed radish (Colonel, 18 lbs./A PLS) and oriental mustard (Pacific Gold, 12 lbs./A PLS) were sown in wheat stubble on a Capac fine sandy loam on 8 August. Three seeding methods were used: (1) conservation tillage with two passes of a combination tillage tool (12-foot Kongskilde Triple-K, 3-inch tillage depth) with a front disk gang, field cultivator teeth, and a rolling basket for soil firming, (2) direct-drilling into undisturbed wheat stubble, and (3) slurry seeding with aeration tillage and seed-laden swine slurry (36,600 gal./A). The plots were arranged in a randomized complete block with four replications. The aerator gang angle was set at 10° for maximum soil fracturing. The tilled-and-drilled and direct-drilled crops were seeded with a Great Plains no-till drill (10-foot width, 7.5-inch opener spacing). Aboveground and root biomass and plant stand (plants m^{-2}) were evaluated on 28 October, 2005.

Kellogg Biological Station, 2005
Oil seed radish (Colonel, 18 lbs./A PLS) and oriental mustard (Pacific Gold, 12 lbs./A PLS) were sown in untilled wheat stubble on an Oshtemo sandy loam (coarse-loamy, mixed, mesic Typic Hapludalfs) on 2 August. Two seeding methods were used with each crop: (1) direct-drilling with a Deere 750 no-till drill (10-foot width, 7.5-inch opener spacing), and (2) slurry seeding with aeration tillage and seed-laden dairy manure. The plots were arranged in a randomized complete block with four replications. The aerator gang angle was set at 7.5° and seed-laden dairy manure was applied at 30,500 gal./A. Aboveground and root biomass and plant stand (plants m^{-2}) were evaluated on 30 October, 2005.

Biosuppressive Cover Crops — Oil Seed Radish and Oriental Mustard

East Lansing, 2004
There were significant effects on plant stand (plants m^{-2}) from both the seeding method and crop sown (Table 2). Direct-drilling (56 plants m^{-2}) led to a greater stand than manure slurry seeding (35 plants m^{-2}; $p = 0.04$). Oriental mustard (71 plant m^{-2}) produced a greater stand than either Com-OSR (32 plants m^{-2}; $p = 0.01$) or Col-OSR (34 plants m^{-2}; $p = 0.01$).

There was a significant seeder X crop interaction ($p = 0.05$) in total biomass production. The manure slurry-seeded OM biomass was significantly greater ($p = 0.03$; 5,309 lbs./A) than the direct-drilled OM biomass (2,757 lbs./A) but there was no significant difference between the OSR varieties. Individual plant biomass with the manure slurry-seeded Com-OSR was 1.5 times greater (117 g $plant^{-1}$ versus 72 g $plant^{-1}$) and the manure slurry-seeded Col-OSR stand was 2.7 times greater than with direct drilling.

East Lansing, 2005
There were significant effects on plant stand from crop sown and seeding method. The direct-drilled OSR stand (153 plants m^{-2}) was significantly greater than the manure slurry-seeded stand (27 plant m^{-2}; $p < 0.01$), and the direct-drilled OM stand (148 plant m^{-2}) was significantly greater than the manure slurry-seeded stand (28 plant m^{-2}; $p < 0.01$; Table 2). There was a significant ($p = 0.01$) seeder X crop interaction in the magnitude of crop response with the tilled-and-drilled seeding method. The tilled-and-drilled (134 plant m^{-2}) and the manure slurry-seeded OM stands (28 plants m^{-2}; $p < 0.01$) were significantly different, but the tilled-and-drilled and direct-drilled OM stands (148 plants m-2) were not different ($p = 0.98$). In contrast, the tilled-and-drilled (42 plants m^{-2}) and the manure slurry-seeded (27 plants m^{-2}) OSR stands were not significantly different ($p = 0.98$), but the tilled-and-drilled and direct-drilled (153 plant m^{-2}) stands were different ($p < 0.01$).

There were no significant differences in OM surface biomass ($p = 0.92$), OSR root biomass ($p = 0.15$) or OSR total biomass ($p = 0.84$) due to the seeding method. Surface OM biomass was 34 g, 31 g and 189 g $plant^{-1}$ with the tilled-and-drilled, direct-drilled, and manure slurry-seeded seeding methods, respectively. Individual OSR plant biomass was 161 g $plant^{-1}$ with manure slurry seeding, 117 g $plant^{-1}$ with till-and-drill and 35 g $plant^{-1}$ with direct drilling.

Kellogg Biological Station, 2005

The direct-drilled OM stand (144 plants m^{-2}) was significantly greater than the manure slurry-seeded OM stand (47 plant m^{-2}; $p < 0.01$), and the direct-drilled OSR stand (65 plants m^{-2}) was significantly greater than the manure slurry-seeded OSR stand (26 plants m^{-2}; $p = 0.03$; table 2).

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 ($p < 0.01$; OSR was greater than OM). The manure slurry-seeded OSR surface biomass (5.16 Mg ha^{-1}) was significantly greater than the direct-drilled OSR ($p = 0.01$; 3.13 Mg ha^{-1}), but the difference between the manure slurry-seeded and direct-drilled OM was not significant ($p = 0.31$).

Table 2. Aboveground and root biomass, and plant stand for oil seed radish and oriental mustard over three years and three locations.[a]

Crop	Seeding Method	Aboveground Biomass, 1,000 lbs./A	Root Biomass, 1,000 lbs./A	Total Biomass, 1,000 lbs./A	Plants m^{-2}
2004 East Lansing					
OM	Slurry	4.7 b	0.56 ab	5.31 a	60 ab
OM	Direct-drill	2.4 a	0.29 b	2.76 b	82 b
Common OSR	Slurry	2.7 a	0.62 ab	3.33 b	26 a
Common OSR	Direct-drill	2.4 a	0.75 a	3.12 b	37 ab
Colonel OSR	Slurry	3.4 a	0.87 a	4.02 ab	19 a
Colonel OSR	Direct-drill	3.2 a	0.82 a	4.02 ab	49 ab
2005 East Lansing					
Colonel OSR	Till-Drill	4.4 a	0.74 a	5.11 a	42 a
Colonel OSR	Slurry	3.9 a	0.95 a	4.82 a	27 a
Colonel OSR	Direct-drill	4.7 a	0.60 a	5.32 a	153 b
OM	Till-Drill	4.1 a	--	--	134 b
OM	Slurry	4.7 a	--	--	28 a
OM	Direct-drill	4.1 a	--	--	148 b
2005 Kellogg Biological Station					
Colonel OSR	Slurry	4.6 a	1.7 a	6.30 a	26 a
Colonel OSR	Direct-drill	2.8 b	1.08b	3.87 b	65 b
OM	Slurry	2.6 b	1.01 b	3.62 bc	47 ab
OM	Direct-drill	1.8 b	0.62 c	2.44 c	144 c

[a] abc letters within columns and locations indicate values not significantly different by Tukey's HSD procedure ($p \leq 0.10$).

Conclusions

Manure slurry-enriched seeding is an environmentally sensitive option for manure management in diverse cropping systems. Aeration tillage creates an absorptive surface that prevents overland flow and soil erosion by fracturing the soil, increasing surface roughness, improving infiltration, and conserving crop residues. In the same pass, nutrient-rich, seed-laden slurry quickly infiltrates the soil matrix, thereby reducing volatile N losses compared to surface spreading. The emerging cover crop traps nutrients and forms a vegetative barrier to overland flow. Soil quality is enhanced by reducing tillage intensity and adding organic inputs — manure and cover crops — that stimulate soil building biological processes.

Manure slurry seeding requires seed placement in suitable seeding micro-sites. From these trials, visual inspection revealed seed germination and emergence through cracks and fissures from depths ranging from near the surface to 2 to 4 in. below the surface. Seed placement was largely influenced by slurry infiltration into fractured soil: untilled, consolidated soil that formed large clods and aggregates in response to aeration tillage triggered deeper placement in cracks and fissures; loose and flowable soils that backfilled the aeration tine opening before the seed-laden slurry was applied caused near-surface seed placement. In earlier work, we noted poor germination and emergence in tilled or loose and flowable soils that did not create well-defined cracks and fissures for seeding micro-sites (unpublished data). Manure slurry-enriched seeding is best suited for untilled ground.

Experimental evaluation of this process in Michigan indicated that:

- Manure slurry-enriched seeding is an efficient and effective establishment method for summer seeding of oil seed radish and oriental mustard in untilled wheat stubble and an environmentally sensitive manure application.
- Manure slurry-enriched plant stands (plants m^{-2}) were often less than those of the conventional seeding, but the biomass yield was generally equal to or greater than the conventional seeding because individual plant biomass was two- to six-times greater with slurry seeding. There were no instances when the biomass production of the no-till drill seeded crop was significantly greater than the manure slurry-seeded crop.

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Reference

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