Final Report

1. Title: Cover Crops for Remediating Compacted Soils
SARE Project #FNE00-~~22~~ 322

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2. Goals. The goals of the project were to demonstrate the use of cover crops in remediating a compacted soil, and to compare on a large-plot scale some of the cover-cropping options most feasible for processing vegetable growers. The demonstration was a follow-up to the SARE-funded project "Management Strategies for Improved Soil Quality with Emphasis on Soil Compaction". Most processing vegetable growers in the state produce wheat as a rotation crop or a cover crop. Many frost-seed clover into the standing wheat in very early spring, and leave the clover to grow past wheat harvest to the following spring. Often, however, frost seeded clover does not "catch", or produce a good stand. We specifically wanted to look at potential ways to improve stand establishment and clover growth, and to compare this frost-seeded clover with other cover crops.

3. Farm Update. L-Brooke Farms has not changed appreciably since the project began. The NY Crop Research Facility, where the project was conducted, has just finished its third growing season as a grower-owned, industry-driven research facility.

4. Cooperators. Lee Stivers, NYCRF manager, served as the main technical advisor and conducted the demonstration at the NY Crop Research Facility. NYCRF is governed by a board of directors representing vegetable producers and processors which oversees projects and activities at the farm. R.B. Glazier, a partner at L-Brooke Farms, sits on this board.

5. Project Activities: The cover crops demonstration was established on approximately 10 acres at NYCRF. The soils in this field had been heavily cropped, primarily in turf, for many years, and was of poor physical, chemical and biological quality. There was a standing crop of wheat in the field when the project started in March, 2000. Soil samples were taken from a number of locations within the 10 acre field and frozen to serve as a baseline. The following is a plot-by-plot description of the NYCRF cover crops demonstration field, 2000-2001. Each plot was approximately ¾ of an acre.

- **Plot 1. Mammoth red clover-early-low (failed)/fallow/field corn.** Mammoth red clover was frost-seeded into standing wheat on 3/21/2000. Seed were broadcast using an ATV-mounted spinner operated by an individual who custom-seeds clover for wheat growers. The seeding rate was 10 lbs/acre. On 4/23, the plot was mistakenly sprayed with a broad-leaf herbicide applied by one of the grower's workers as he covered all wheat acreage. The plot was observed for several weeks, but it was clear that the herbicide killed the newly sprouted clover. This plot was abandoned for demonstration purposes, and was disked and planted to field corn in May, 2001.

- **Plot 2. Mammoth red clover-early-high (failed)/sudangrass/field corn.** This plot was seeded exactly as Plot 1 on 3/21/2000, except at a seeding rate of 15 lbs./acre. Herbicide was also mistakenly applied on 4/23. On 5/1, Round-Up herbicide was applied to kill the growing wheat, and the plot was plowed on 5/3. Sudangrass was planted on 7/12 on at a seeding rate of 50 lbs./acre using a disk-type grain drill. Sudangrass biomass was sampled on August 31, and the plot was mowed with a bush-hog. Re-growth was sampled on September 28, and the plot was then disked prior to frost. The plot was disked and planted to field corn in May, 2001.

- **Plot 3. Medium red clover-early-low (failed)/ fall-seeded clovers/field corn.** This plot was seeded exactly as Plot 1 on 3/21/200, except with medium red clover. Herbicide was also mistakenly applied on 4/23. On 5/1, Round-Up herbicide was applied to kill the growing wheat, and the plot was plowed on 5/3. The plot lay fallow for the summer, then was disked up on 9/8. One quarter of the plot was planted to yellow-blossom sweet clover (10 lbs./acre) and the rest to medium red clover (10 lbs./acre) and lightly harrowed. Growth from these fall-seeded clovers was very poor, and the plot was disked and planted to field corn in May, 2001.

- **Plot 4. Medium red clover-early-high (failed)/buckwheat/vetch and rye/sweet corn**. This plot was seeded exactly as Plot 1 on 3/21/200, except with medium red clover at the higher seeding rate of 15 lbs./acre. Herbicide was also mistakenly applied on 4/23. On 5/1, Round-Up herbicide was applied to kill the growing wheat, and the plot was plowed on 5/3. Buckwheat was planted on 7/12 at a seeding rate of 60 lbs./acre using a disk-type grain drill. Buckwheat biomass was sampled on August 25, and the cover crop was disked under before setting seed. The plot was then split, with approximately half being planted to hairy vetch (40 lbs./acre) and half to a vetch—rye mixture (50%-50% by weight). The vetch seed was secured from Steve Groff in Pennsylvania, and was reportedly more winter-hardy than other strains of vetch. Fall growth was sampled on 10/31, and spring re-growth sampled 5/21/2001. By this time the rye had headed out, and the field was bush-hogged on 5/24. The plot was plowed on 6/5 and the vetch half planted to sweet corn. No herbicides were applied to the sweet corn, which was cultivated once during the summer.

- **Plot 5. Fallow.** This plot was left fallow for the entire period of the demonstration. It grew up to a mix of volunteer wheat and weeds.

- **Plot 6. Mammoth red clover-late-low/field corn.** Mammoth red clover was frost-seeded into standing wheat on 5/4/2000 by the same custom seeder at a rate of 10 lbs./acre. Stand and subsequent growth were good over the summer, but survival and regrowth in the spring were poor. Therefore, the plot was disked and planted to field corn in May, 2001.

- **Plot 7. Mammoth red clover-late-high/field corn.** Mammoth red clover was frost-seeded into standing wheat on 5/4/2000 by the same custom seeder at a rate of 15 lbs./acre. Stand and subsequent growth were good over the summer, but survival and regrowth in the spring were poor. Therefore, the plot was disked and planted to field corn in May, 2001.

- **Plot 8. Medium red clover-late-low.** Mammoth red clover was frost-seeded into standing wheat on 5/4/2000 by the same custom seeder at a rate of 10 lbs./acre. Stands and growth were good over the summer, and biomass samples were collected on 10/31 and 5/21/2001. The plot was mowed with a bush-hog on 5/24 and allowed to regrow through the summer. However, the extreme drought during that second summer resulted in poor growth. The plot was disked under in September and planted to wheat.

- **Plot 9. Medium red clover-late-high.** Mammoth red clover was frost-seeded into standing wheat on 5/4/2000 by the same custom seeder at a rate of 15 lbs./acre. Stands and growth were good over the summer, and biomass samples were collected on 10/31 and 5/21/2001. The plot was mowed with a bush-hog on 5/24 and allowed to regrow through the summer. However, the extreme drought during that second summer resulted in poor growth. The plot was disked under in September and planted to wheat.

6. Findings and accomplishments. Results of cover crop biomass inputs are shown in Tables 1 and 2, below. Originally we were attempting to make comparisons of different cover crops, particularly frost-seeded clovers, planted at different times and different rates. That approach had to be changed after all four early-planted clover plots were mistakenly sprayed with a broadleaf herbicide. While this event compromised the original intent, it did underscore the need to find cover-cropping systems that are compatible with current production practices. Thus, if producers are typically applying herbicides to wheat early in the season, then early frost-seeding of clovers may not be a practice producers could adopt. To compensate for the lost clover plots, we planted several annual cover crops (sudangrass, buckwheat, yellow blossom sweet clover, rye and vetch) to compare with the clover plots we still had to work with.

Table 1: Biomass samples of cover crops, 2000-2001. At each date except for 7/27/00, three 2 ft.2 quadrat samples per plot were collected, dried in a tissue oven and weighed to estimate dry matter production. Samples on 7/27/00 were weighed fresh, without drying. Fresh weights were converted to dry weights by assuming that fresh plant material was 95% water.

Date	Plot Number	Cover Crop	Dry Matter tons/acre
7/27/00	6	mammoth red clover, late, low	1.7
7/27/00	7	mammoth red clover, late, high	1.8
7/27/00	8	medium red clover, late, low	1.5
7/27/00	9	medium red clover, late, high	2.5
8/25/00	4	buckwheat	3.8
8/31/00	2	sudangrass	3.8
9/28/00	2	sudangrass	2.0
10/31/00	4a	vetch	0.2
10/31/00	4b	rye and vetch	1.4
10/31/00	5	wheat stubble	2.4
10/31/00	5	volunteer wheat	0.3
10/31/00	8	medium red clover low	3.9
10/31/00	8	wheat stubble	1.5
10/31/00	9	medium red clover high	3.3
10/31/00	9	wheat stubble	1.3
5/21/01	4a	vetch	3.8
5/21/01	4b	rye and vetch	7.2
5/21/01	8	medium red clover low	4.0
5/21/01	9	medium red clover high	4.8

Table 2: Overview of biomass inputs provided by several cover crop combinations, 2000-2001.

Plot Number	Plot Rotation (fall 99 - summer 01)	Biomass Inputs, tons dry matter/acre			
		Jul/Aug 2000	Sept/Oct 2000	May 2001	Total
1	wheat-fallow-fallow-field corn	0	0	0	0
2	wheat-sudangrass-field corn	3.8	2.0	--	5.8
5	wheat-volunteer wheat-fallow	--	2.7	--	2.7
9	wheat-medium red clover-clover regrowth	1.8	4.6	4.8	11.2
4a	wheat-buckwheat-hairy vetch-sweet corn	3.8	~~1.4~~ 0.2	3.8	9.0
4b	wheat-buckwheat-rye+hairy vetch-fallow	3.8	~~0.2~~ 1.4	7.2	11.2

We observed the following in conducting this demonstration:

- medium red clover survived the winter of 2000-2001 (relatively severe) better than mammoth red clover.
- increasing the seeding rate of medium red clover from 10 lbs./acre to 15 lbs./acre increased dry matter production in both the first and second years.
- spring frost-seeding of clovers into wheat was much more successful than fall seeding onto bare ground.
- frost-seeding clovers into wheat must be carefully timed to occur after any herbicide applications to the wheat.
- in a single year, sudangrass can produce as much dry matter as a well established clover stand, but in less time. Plot 2 (sudangrass) produced approximately as much biomass from July through September, 2000, as did plot 9 (red clover) from March through October.
- over the course of the entire year and a half, no cover crop combination tested in this demonstration out-produced a good stand of medium red clover (plot 9).
- it took a combination of three annual cover crops (plot 4b), requiring considerably more tillage and planting passes, to equal the dry matter production of a good stand of medium red clover.
- groundcover was constant with the frost-seeded clover plantings. Annual cover crops, while allowing more flexibility for integrating with cash crops, always required tillage and a period in which the soil was exposed.
- hairy vetch planted alone did not provide a great deal of groundcover over winter. However, it survived the tough winter very well and produced a considerable amount of spring re-growth.
- in this demonstration, the rye greatly out-competed the vetch when they were grown in combination. While vetch seedlings were quite evident in this plot in the fall, during the spring re-growth the rye greatly dominated the plot. This is surprising since the conventional wisdom is that in poorer soils, vetch will compete better with rye since it is not dependent on soil nitrogen.
- it is extremely difficult to manage a rye cover crop if it has been allowed to head-out before incorporation. Even after bush-hogging the rye in late May, we were unable to get it properly incorporated into the soil well enough to plant anything back into the plot. The extreme lack of rainfall made the situation worse, and that section of the plot was left fallow over the summer of 2001.
- relying on a winter vetch cover crop and cultivation alone did not provide adequate weed control for sweet corn during the dry summer on this poor soil. Early in the season, weed control in the sweet corn looked very good considering there had been no herbicide applications. However, the lack of rainfall resulted in such poor sweet corn growth that weeds had gotten completely out of control by August.

7. Conditions affecting the outcome. As mentioned above, we did encounter several unexpected conditions that affected the outcome of the project. These include the unintended herbicide application to four of the plots, the very wet growing season of 2000 which kept us from planting more cover crops at different timings, and the extremely dry growing season of 2001. The difficult growing seasons also limited to some degree the amount of time and attention we could pay to the demonstration plots.

8. Economic findings. We did not set out to make any economic determinations with this project.

9. New ideas to solve the problem. More work needs to be done in the area of remediating compacted, poor quality soils. It is clear from this project and other work that cover crops can be an important part of the solution, but will probably not be a stand-alone solution, particularly in the northeast where the growing season is limited.

10. Continuing the investigated practice. We have used frost-seeded clover in wheat for many years and will continue to do so. Other cover crops were looked at in this trial but none surpassed our current practice of frost-seeding medium red clover into wheat, either in biomass produced or ease of management. The key to success with this practice is timing the seeding to get a good stand.

11. Outreach. Outreach activities were also coordinated through the activities of the New York Crop Research Facility. They were as follows:

- The cover crop plots were featured at the NYCRF Field Day on August 23, 2000 (see attached meeting agenda and handout). This meeting drew over 100 people, although the number had decreased by the end of the program to about fifty. Signs were posted in each plot, and a brief description of the project was given. Attendees were encouraged to view the plots and different cover crops.
- The plots were again featured at the joint Cooperative Extension/NYCRF Processing Vegetable Twilight Meeting on July 12, 2001 (see attached meeting agenda and handout). Approximately thirty people were in attendance. At this time, Lee Stivers gave a more thorough description of the project, and Alan Erb from Cooperative Extension discussed the value of using cover crops in vegetable production. He also described Steve Groff's system of cover cropping and organic matter management, and encouraged growers to attend on of Steve's field days in Pennsylvania. Lee Stivers also did a couple of demonstrations from "Soil Health Demonstration Protocols", by Laurie Drinkwater, Carolyn Reider, and Sandra Connelly (Rodale Institute). Using clods of soil collected that week from several different plots as well as those from the original soil sampling in March, 2000, Lee demonstrated the differences in macro-organic matter floatation. Differences in aggregate stability were clearly demonstrated using the "fish bowl" technique. Air-dried clods from different plots were gently lowered into glass jars of water arranged on the tailgate of a pick-up for everyone to see. The clods from before any cover crops were planted, and those from plot 1 (fallow-field corn) quickly disintegrated, sending up large air bubbles in the process. In contrast, clods from several plots with organic matter inputs mostly retained their integrity, slaking only slightly.

- A newsletter article summarizing the project and its observations is currently being distributed to Cornell Cooperative Extension agents throughout the state. A copy is attached. We have also included several slides of the cover crops and of the soils demonstration from the July 12, 2001 meeting.

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October 5, 2001