Cover crops for improving soil health in sweet corn

Final Report for FNE05-552

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Project Leader:

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Project Information

Summary:

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Report Summary

The goal of the project was to trial sorghum-sudan grass followed by an oats/vetch mixture to improve soil fertility and reduce the need for synthetic fertilizers for sweet
corn.

Sudan grass was broadcast onto three trials fields in the spring of 2005. The sudan grass was mowed during the season, and then incorporated at the end of the summer. Oats/vetch was then broadcast and allowed to winter over. This crop was incorporated in the spring of 2006 and sweet corn was planted. Heavy rain just after the corn plantings severely affected growth. The rain, combined with the high amounts of biomass residue from the sudan grass, caused total corn yield to suffer. Soil test results did not show any short term gains in soil nutrient levels or organic matter percentages. However, perennial weed pressure was severely reduced in one of the trial fields, most likely the result of the sudan grass out-competing the perennial quack grass.

While not an outright success, the cover crops grew well overall and the methods used seem appropriate for our stated goals. We did not reduce any chemical use during this study but we believe in the future we will be able to reduce both herbicide and fertilizer use. Fallowing the fields for a 2nd season with red clover, might provide actual gains and in usable N credits, and possibly yield higher organic matter content over time.

Goals

To trial and adopt new cover crops to increase soil fertility and organic matter content. We plan to take half of three fields out of production for one season and grow Sorghum-sudan grass during the summer months. At the end of the summer it will be incorporated and an oats/vetch mixture will be broadcast. The following season the vetch will be disked in and sweet corn planted on each of the trial fields. We are hopeful that through the use of these new cover crops, we will reduce the need for synthetic fertilizers while also reducing weed and pest pressure.

Farm Profile

Verrill Farm has been a working farm since 1918. Up until 1990 the farm operated primarily as a dairy with 150 milking cows and 130+ acres in grain production. In 1990 the cows were sold and efforts were directed toward building a retail vegetable enterprise. The farm now operates a year-round farm stand which includes a retail sales floor and a full commercial kitchen with deli.

The crops produced on the farm are sold through the farm stand and to Boston area restaurants. In any given year we grow approximately 110 acres of mixed vegetables. The crop mix is varied but includes: sweet com (70 acres), pumpkins (10+ acres), winter squash (10 acres), potatoes (3 acres), cucurbits (5 acres), tomatoes (3 acres), lettuce (3 acres), root crops (2 acres), and smaller amounts of herbs, greens, flowers, and small fruits. The farm boards 30 horses which are managed as a separate enterprise, with the horse manure being composted on-site for use as fertility in the vegetable fields.

Participants

Our technical advisor is Jim Mussoni. He has been employed by the farm for many years as our crop scout and advisor. Jim has taken most of the soil samples for this project and as a general advisor. There has not been a great need for any technical expertise for the project implementation.

Project Activities

Three fields have been chosen to implement the cover crop trials. The field names and sizes are: Lincoln Field - 7 acres, Bigelow Field - 9 acres, and White Pond Field - 6 acres (see satellite maps, attached). All fields are physically distant from one another but each has uniform ground and soil types. An attempt was made to prepare and treat each field identically throughout the research process. However due to unforeseen circumstances some dates and methods of the actual working of the fields varied slightly. All of these variations will be noted throughout this report.

In 2005 each of these fields were split into two sections. One section received the new cover crop treatment and one section was treated with our normal farming practices and planted to sweet corn or another crop. In the spring Sudan grass was used at a rate of 451b/acre (.57/lb). Following the Sudan, Oats @ 70 Ib/acre (.27/lb) and Vetch @ 40 Ib/acre ($1.601b) will be spread on these same fields. In 2006 all the trial fields will be planted to sweet corn. Soil tests will be taken and results compared to previous tests. Sweet corn yield and other observations will be made during the season. This information will be included at the endof the project.

On May 13th soil tests were taken to capture baseline information. The soil tests recommended the addition of nitrogen for proper growth/yield of the cover crop. This was not foreseen to be needed in the original project proposal. After consulting with our advisor, Jim Mussoni, we agreed to spread Urea 46-0-0 at a rate of SOlbs of nitrogen per acre for all of the fields to receive the Sudan grass. The Urea cost was $10.68 per fifty pound bag, which equals $21.40 per acre. Approximately 11 acres are included in this trial which resulted in $235.40 in additional expenditures for the urea. The farm absorbed this cost. To spread the materials we used a Vicon PTO powered broadcast spreader. The spreading took approximately five minutes per

acre. An additional five minutes per acre was needed to lightly incorporate the amendments using a 13'wide Perfecta II. Spreading and incorporating in different steps was intentional so we could ensure accurate seeding rates.
It should be noted that it was a colder than normal spring, with the month of May averaging 6 degrees F cooler than normal, with 21% more precipitation than average (see attached weather information). There was some concern that the cool spring would hamper the germination and growth of the Sudan grass. Soil temps at the time were less than 58 F. But it was getting late into May, so we decided to move forward and sow the crop, hoping germination would be adequate. The forecast indicated a warming trend, with temps reaching into the 70's. This forecast proved correct. The warming trend and rain was seen to be an asset in allowing uniform germination and good growth.

Once all the fields were spread with the Sudan grass, weekly observations were made as to growth of the cover as well as weed pressure. At the end of this report are several worksheets used to document the cover crop growth on all the fields. These are called "Cover Crop Screening Data Sheets" and they were adopted from Marianne Sarrantonios' Northeast Cover Crop Handbook. The information gathered in these data sheets includes date of seeding, growth and vigor, weed competition, mowing and incorporation. Each field will be reported on separately. The data sheets also contain comments and observations. In general, within two weeks the Sudan grass germinated and was approximately 1-2" tall. Within three weeks the Sudan was 6" tall with weeds such as Lambsquarter, Redroot Pigweed, and Ragweed beginning to compete. In all cases the Sudan grass outgrew the weeds with weed groundcover achieving 25% at most. The Sudan was mowed at four feet in height and allowed to re-grow before final incorporation.

The weather during the season was unseasonably warm and dry. Throughout this trial it is believed that the Sudan grass may have been both helped and hindered by the unusual weather. The most notable observation was after the mowing of the Sudan. The dry conditions appear to have slowed re-growth, most notably in the White Pond field. For the readers' information, graphs of precipitation and temperatures during the season are shown at the end of this report. Included in these graphs are the dates when sowings, mowings, and tillage occurred.

- Bigelow Field, Spring 2005 -

The first field to begin this trial was our earliest corn field, Bigelow Field (6.5 acres in corn, 2.40 acres for the new cover crops). The entire field was plowed on April 8th with a 5-bottom moldboard plow. The stand of rye which over wintered was further incorporated with a heavy disk harrow. On May 23rd the urea and sudan grass were spread using a Vicon PTO powered spreader. Calibration issues occurred during this first spreading since the spreader was new to the farm. After several adjustments it was concluded that a setting of #8 on the spreader, driven at a rate of 5.5 to 6mph was the proper rate for spreading the sudan grass at 45#/acre. A setting of #12-14 was correct for spreading the urea at a rate of lOOlbs (of material) per acre, driven at the same speed Needless to say this first spreading was a bit uneven which can be seen in the accompanying photos of the field. The urea and sudan grass were lightly incorporated using a 13' wide Perfecta II harrow.

By July 11th the sudan grass varied in height from 40 to 60" tall. The cover crop was mowed down to a height often inches, with the expectation that the root system and above ground biomass would increase. The mowing was done with a six foot wide rear-mounted rotary mower. The mowing went well. Some areas under the tire tracks were not cut due to the tractor tires rolling the grass before the mower could chop it down. The grass which rolled under the tire tracks bounced back and resumed growing, but this did not pose a problem. Within two weeks the grass was

re-growing vigorously and within three weeks it reached 3-4 feet in height across most of the field, with stronger wider roots and thicker stalks.

On August 2nd it was decided to disk down the sudan a couple weeks earlier than planned. This was to see how the sudan would respond to a heavy disking before we applied the same methods to the other trial fields. The disking was done with a 16' wide heavy disk, using a 1 lOhp 4wd Massey Ferguson. At the time of disking, the cover crop to follow the sudan was also spread using the Vicon spreader; vetch at 401bs/acre and oats at 70/acre. The disking appeared to go well with most of the sudan being fully incorporated.

At the time of disking quadrat cuts were made to determine biomass. The sudan was 36" high at the time of the sampling. Fresh weight averaged 2.65 pounds. This equals 29,150 lb fresh weight/acre (14.5 tons/acre) which in turn equals 72881bs dry weight per acre. Since this sampling was made after the second cut it can be assumed that this figure can be doubled if we are to account for the material prior to the mowing. In the SAKE publication Managing Cover Crops Profitably Sorghum-Sudan grass is listed as potentially contributing 8-10,000 lb dry weight per acre. Our calculations fall within these estimates - particularly if the weight of the sudan, pre-mowing, is considered in the
calculation.

- Bigelow Field, Fall 2005 -

Within two weeks it was obvious that the sudan grass was not killed with the disking. Instead, the grass began to re-root and grow once again. The oats sowed at the time of disking seemed to be suppressed, perhaps alleleopathically. Oats germination was extremely low in the main part of the field, but on the edges where the sudan was not present, the oats germinated normally. Interestingly, the vetch was not suppressed. Germination of the vetch was good, though hampered slightly by the vigorous growth of the Sudan grass, which shaded out the vetch.
As of October 2005, the vetch reached heights of two feet, and the Sudan reached five feet in spots. Oats are noticeable only on the field edges.

- Bigelow Field, Spring 2006 -

On April 7th the field was disked followed by the Perfecta field cultivator. There was a tremendous amount of woody trash on the surface from the winter-killed sudan grass. It was not our intention to allow the sudan grass to over winter as it did, but because we had difficulty incorporating it in the fall and the oats/vetch never came up as expected, it was decided we would leave the sudan as a winter cover to at least protect the soil. We were concerned that if the sudan was plowed again, more aggressively, the field might be too exposed over the winter. In hindsight, this may have been a better option. Incorporating the woody sudan trash was extremely difficult and took several passes with the heavy disk to break it down to an acceptable level.

The field was allowed to rest for a week, and then, on April 13th, the sweet corn was planted. We used a Monosem vacuum seeder and banded the seed with corn starter fertilizer (10-20-10) at a rate of 300 lb/acre.

It should be noted that significant organic matter was in the first several inches of the soil, especially as compared to previous years. Seed germination was spotty in the trial portion of the field. We could not determine if this was caused by the unusually dry spring or because of poor seed to soil contact exasperated by the high amounts of woody organic material, or a combination of the two. Either way, seed germination was poor and the resulting sweet corn stand was week. Final results are discussed in the results portion of the report.

- Lincoln Field -

On April 15th the entire Lincoln Field (4.5 acres for trial, 2.5 acres in potatoes/control) was plowed using a five bottom moldboard plow. This was followed by a light disking.

On May 23rd, immediately after the Bigelow Field applications, this field was spread with urea and the Sudan grass, using the same rates and methods previously used. The spreading was done evenly and accurately. Following the spreading, a Perfecta II was used to lightly incorporate both the urea and Sudan grass. It began to rain late in the afternoon. Over the next week it rained over two inches with average air temperatures in the low 60's.

Of note, there was significant weed growth throughout most of the field. Lambsquarter and redroot pigweed were the main weeds. They competed successfully until the mowing of the Sudan on July 11th. The weeds produced seed heads by the time of mowing, but the seeds did not reach maturity. The mowing operation was similar to that at Bigelow field with some Sudan being rolled by the wheels without being cut. Mowing duration was 3.5 hours. The re-growth of the Sudan in this field was substantial. In part because re-growth was allowed to occur for six weeks, several weeks longer than in Bigelow field.

It was decided to plow down the Sudan with the moldboard plow to eliminate any possibility of re-growth (as was experienced at Bigelow field). On August 28th the Sudan was plowed under. In many areas of the field it was over six feet in height and very thick. Quadrat cuts were made at the time of mowing and at final plow-down to assess organic matter. Yields were much higher than in Bigelow field, and exceeded the yield estimates of 8-10,000 lb/acre as indicated in Managing Cover Crops Profitably.

Table 1. Lincoln, quadrat cut
.....July 11.....August 25
Height at sample time.....5-6'.....6-8'
Quadrat cut weight.....4 lb.....4.5 lb
Fresh weight (yield/A).....44,000 lb...49,500 lb
Dry weight (yield/A).....11,000 lb...12,375 lb

- Lincoln Field, Fall 2005 -

On September 2nd the field was broadcast with oats and vetch and lightly incorporated. The growth was good, with both covers germinating and 2" in height within two weeks. By the end of October the oats/vetch reached heights up to 20" with % ground cover reaching 75%. The primary weeds remain lambquarters and redroot pigweed which reached up to 20% of the ground cover.
Lincoln Field, Spring 2006

On May 7th the entire field was disked several times followed by the Perfecta 2. On the
trial portion of the field, the vetch was quite dense and lush. The control portion had some rye which was growing nicely but was only several inches tall before being incorporated. The rye was sown late in the fall which limited it's growth before the onset of winter. On May 11th fte sweet com was planted to the entire field. Corn starter fertilizer was banded with the seed.
Growth was similarly poor across the entire field. Due to unusually heavy spring rains, many seeds either washed away, rotted, or were flooded.

- White Pond Field, Spring 2005 -

White Pond field (3.5 acres trial, 2.5 acres sweet com/control) was plowed on May 22nd with a five bottom moldboard plow. A stand of winter rye with 10% vetch was on the field prior to plowing. Quadrat cuts were made of the rye/vetch to get a biomass estimate. Two cuts were made with the average weighing 2.051bs. Using

formulas from The Northeast Cover Crop Handbook the cover yielded 22,6051bs of fresh material with a dry weight of 4,521 lbs per acre. On May 23rd the field was harrowed with a 13' Perfecta II to smooth the surface. On May 27th Urea and the Sudan were broadcast evenly, using the same rates as on the other fields and lightly incorporated.

Growth in this field was not as vigorous as the other fields. The Sudan did not appear to have sufficient nitrogen, as there was significant color variation within the field, some areas light/pale green, others darker green. We decided not to add additional nitrogen. On July 18 the Sudan reached a height of 4-5'. It was then mowed down with flail mower. A neighboring farmer mowed this field with a 12' wide flail mower. We wanted to see if there was any difference in how the crop reacted to mowing. Re-growth was not as vigorous but this was thought to be attributed more to the dry conditions than the flail mowing. There was no rain for two weeks following the mowing. On August 26 the Sudan grass was plowed under with a moldboard plow. Quadrat cuts were made to determine dry weight yield. Yield information is as follows:

Table 2. White Pond, quadrat cut
.....July 18.....August 26
Height at sample time.....5-6'.....6-8'
Quadrat cut weight.....4 lb.....4.5 lb
Fresh weight (yield/A).....44,000 lb...49,500 lb
Dry weight (yield/A).....11,000 lb...12,375 lb

- White Pond Field, Fall 2005 -

On September 2nd the field was lightly disked. Oats and Vetch were broadcast and lightly incorporated. Growth of the cover was good. Rainfall increased during September aiding germination. Within three weeks the oats/vetch were 6-8 inches tall and by the end of October 14-24 inches with 70% ground cover. Weed competition was mostly Lambs Quarters and covered perhaps 15% of the field.

- White Pond Field, Spring 2006 -

White pond field was moldboard plowed on April 20th, followed by perfecta. The field was then planted horizontally across both the trial and control fields. This was done to more easily determine, visually, if there were growth variations between the two. The field was planted to sweet corn on April 25th. Corn starter fertilizer (10-20-10) was banded with the corn seed at a rate of 3001bs per acre.
Growth was similar in both plots. The most outstanding difference was a clear delineation in weed pressure between the fields. This will be elaborated upon in the results section.

Results

We experienced an unexpected amount of rain in the spring of 2006. This unusual weather seriously affected the outcome of the results. Yields of corn across all our fields, not just the grant fields, were affected. Nitrogen leaching occurred and plants were stunted for several weeks following the rain. Additional chemical fertilizers were used to stimulate growth and attain adequate yields. Due to this unusual event, we did not measure corn yields, as it was felt they would not evenly reflect varying field conditions.

Several important observations were made despite the wet spring:

Bigelow - Allowing sudan grass to winter-kill without incorporation severely affected the growth of the corn. Ensuring the sudan grass is completely incorporated after plow down is essential. We believe the extremely high C/N ratio of the sudan grass, combined with the over wintering of the sudan on the surface, then incorporated

prior to planting, prevented the corn seeds from germinating and inhibited their normal growth. The large amount of woody material led to a depression of nitrogen availability. The resulting com crop was weak and barely reached maturity. We experienced a 50% reduction in marketable corn. The irony is the control portion of the field did extremely well. An excellent stand of vetch was incorporated in the spring and provided an excellent crop of corn.

Lincoln - Throughout the entire field yield was poor, as compared to previous years. Despite excellent cover crops in 2005, no improvement in the corn was found. There was some upwards fluctuation in organic matter content as shown in the soil tests, but it is difficult to assign any reason to this. The wet spring and the slope of the field led to excessive flooding at the base of the field, considerable erosion, and poor germination/groth. Once the corn recovered after the heavy rain, yields were average to below average.

White Pond - Perhaps the most interesting observation occurred in this field. We noticed a clear weed pressure difference between the control and trial fields. As if someone drew a line down the middle of the field, weed pressure was almost non-existent on the trial side while extremely strong on the control portion. Quack grass was so competitive on the control portion of the field, despite herbicide use, that the corn crop yielded very little marketable corn. In the trial portion there were almost no weeds and the resulting crop was quite good. The only explanation for this that we've found is that the sudan grass smothered the quack grass reserves so effectively during the previous summer, that it caused the stolons which over-wintered to be extremely week and vulnerable to both herbicide use and cultivation.

For all the fields, soil tests were taken several times throughout the grant. As compared to soil tests from the previous two years, no significant changes occurred in any of the
fields. See attachments.

Conditions

In 2005, and as described previously, it was a warm and dry season. This proved to be an issue especially during critical periods when we were sowing the cover crops and mowing. Re-growth of the sudan grass was definitely affected by the reduced rainfall. In some fields more than others, re-growth was significantly slowed.

In 2006, we had very unusual weather. The spring began very dry with 35% less rain then normal. This was followed by an extremely wet late spring. We received almost 10 inches of rain in May and 10 more inches in June. This is almost 3x the normal rain for the region. All crops were severely affected. In is our opinion that the high C/N ratio of the sudan grass tied up nitrogen in the early spring, and then the heavy rains leached what nitrogen was available in the soil. These two factors contributed to stunted corn and overall reduced yields.

See attached weather data for actual weather information.

Economics

The need to supplement with nitrogen to ensure a good stand of the sudan grass is something to keep in mind. We weren't anticipating this need and additional expense. And even with the added nitrogen, the sudan grass still seemed, in some fields, to be stunted. It may prove to be a better idea to grow nitrogen fixing crops prior to a heavy feeder like sudan grass.

Mowing of the cover was also something to keep in mind. During the season when there is so much to do, it can be tough to find the time to mow. The cost of fiiel and labor to cut the cover crop should be considered. Perhaps other covers that need less management, still provide high biomass, and are N fixers would serve just as

well. Clovers could be viable alternatives. If we owned a wider flail mower, this would have helped to reduce operator and equipment time.

Sweet corn yield data and potential fertilizer savings could not be accurately determined due to the unusual weather in 2006. The excessive rain leached N from the soils causing us to fertilize more than anticipated. And as mentioned above, the high C/N ratio of the sudan grass no doubt contributed to the N tie-up. Many studies support this hypothesis. However, with all this said, it is still thought that with the proper rotation, cover crops could certainly provide the majority of the nutrient needs for a heavy feeding crop such as sweet corn. As petroleum based fertilizers rise in price, the use of N fixing cover crops will become an even more attractive alternative and will no doubt become much more competitive economically.

Assessment

The results of the trials, while not overwhelmingly positive, have created some interesting opportunities for us to explore in the future. It was interesting how slight variations in how we managed the cover crops affected the overall yield and vigor of those same cover crops. For example, the re-growth of the sudan grass was excellent if the mowing was followed by rain. This seemed to give the grass a boost in re-growth and allowed it to provide quicker ground cover and shade the soil, thus conserving soil moisture for sustained growth.

Interestingly, even though we did not see any yield/growth differences from this trial, there has been a shift in our thinking about cover crops. I think that just seeing these new cover crops grow so well, that we have more confidence that they will contribute to the long term health of the soil. It will, however, take some time before there is genuine confidence on the part of the more conventional farmers, that the nutrients from cover crops can indeed replace the need for synthetics. But I surmise that with time, the confidence will arrive.

Adoption

It was tough to determine if the trial would have been more a success if we didn't have such high rainfall. We did gain much more confidence in cover crops and the understanding that timing is extremely vital to success. The soil test data did not show significant gains in any area but there may be other longer-term benefits not immediately apparent. This being said, just trying new covers has opened the farm to consider alternative farming practices. And as mentioned above, in 2006, we experimented with more cover crops than ever before. For example, we trialed fallow fields with oats over seeded to red clover; oats and peas for an early crop of pea tendrils (which was very successful); planted a late summer field to oats/peas to be followed in the spring with strawberries; under-seeded red clover into our u-pick pumpkin patch; sowed Dutch white clover between rows of plastic in lieu of herbicides; and even planted another field to sudan grass.

I am not sure if we will continue the practice of the sudan followed by the oats/vetch for all sweet corn fields. But there is no doubt it will continue to be used in some fashion. We are more mindful of the nitrogen sink created by the sudan grass and ways to mitigate this effect. Perhaps in the future we will fallow those fields which were in the sudan for two years and use red clover to allow the sudan biomass to further breakdown. I suspect in the third year after the sudan, oats/vetch, and red clover.. .that the field(s) would be in prime shape for a sweet corn crop both in nutrient accumulation and reduced weed pressure.

Outreach

We hosted a Eastern-Mass CRAFT meeting on June 15th. (CRAFT is a group of local area farms/farmers who collaborate to share ideas and learn from one another). Approximately thirty farmers and apprentices attending the meeting. The grant

proposal was explained in detail, with copies handed to all. A tour of one of the fields was done showing the Sudan growing-in-action. The beaded string method was also demonstrated which was helpful to many. After the tour, a question and answer session was held.

Due to scheduling difficulties the 2nd CRAFT meeting was not held. But information on the grant will be posted to the farm website and other information sessions will be held informally, in 2007.

Peter Lowy
November 14, 2006

Research

Participation Summary