Final Report for FNE01-397: Two Approaches to Farm-Grown Nitrogen

Goals Restated

During the growing season, I wanted an easily applied, inexpensive organic nitrogen source for certain vegetables that always seem to be short of it. Also, as organic certifiers now discourage the use of blood (and bone) meal due to unanswered questions about Mad Cow Disease, organic farmers need to find reliable replacements for nitrogen sources. I wanted to evaluate the agronomics of on-farm grown legumes (alfalfa/clover) and legume (alfalfa/clover) mulch hay in a controlled and scientific manner.

Farm Info Updated

Since this project began, we've purchased a couple more adjacent acres but our farming configuration remains the same. In 2001, we grew 22 mixed vegetable shares and just completed our fourth year of operating a CSA-type farm for which we have received our second year of certified organic status.

Collaborators and Their Roles

Our collaborators were Tom Basden, WVU Extension Specialist in nutrient management, and Tom McConnell, WVU Extension Specialist in farm management. Mr. McConnell also served as our Technical Advisor. Both individuals were essential to this project, Basden in helping me understand and properly test for nitrogen and McConnell in guiding and consulting with us on how to establish a legume hay field and appropriate equipment to use. Both visited the farm throughout the growing season at our request to help answer questions, Basden about the maturity of the basil petioles and if I was doing the nitrogen test correctly. In the 2 acre field, McConnell taught us how to know when to clip the weeds to reduce competition and helped us think through the other logistics regarding actually making the hay. The title for this project might sound simple, but I didn't realize how much work it would take to just establish a legume hay field. Mr. McConnell helped us take the practical steps needed to manage this project and gave us assurances when we were uncertain.

What We Did and How

One Approach to Farm Grown Nitrogen

We followed the schedule of activities laid out in the grant as closely as possible beginning with a Fall 2000 soil test of the proposed 2 acre field. It showed that the field had a 5.1 pH, 29 P (med), 338 K (very high) and low- to medium- magnesium. In the fall, we mowed the 7' tall weeds which had grown up over 20 some years of neglect. Then we applied 2 tons/acre of high magnesium (dolomitic) limestone and, in the spring, applied 2 tons/acre calcitic limestone to correct the pH. The spring application was worked into the top 2" to 3" of soil with our Massey Ferguson tractor with a PTO driven rear tiller. Per our technical advisor, both actions served to give the legumes a boost--"sweet" soil at the root zone once the seedlings germinated and a fine seed bed onto which to sow the likewise fine alfalfa and cover seed. The high potash reading ruled out the need to apply any. We further prepared the field by applying 500 pounds of colloidal phosphorus and finally had done all we could to correct the soil according to the test results. Much of this work was delayed until mid to late April due to very wet conditions.

On April 30, the 2 acre legume seedbed was ready. By May 4, I had seeded 1 acre of "Gem" var. alfalfa (pre-inoculated) at a rate of 20 pounds per acre; 1 acre of "Cinnamon" var. red clover (inoculated on-site) at a rate of 12 pounds per acre; and had seeded the entire 2 acres with a nurse crop of oats at a rate of 1 bushel/acre. This I did with a hand-crank broadcast seeder. I "seated" the seeds after sowing with a roller fabricated on-farm (see image file 1). The roller consisted of a water-filled, plastic 55-gallon wine grape juice barrel, pulled behind our John Deere "Gator." I rolled the oats east/west and rolled the legumes north/south (see image file 2). Then we waited for the rain to come.

On June 26, we topped the weed heads using a 6' brush hog behind the tractor. The mower was set up as high as it would go (see weed management photos 1-3 sent by U.S. Mail). We had a nasty patch of thistles in the NW corner and dock and hemp dogbane scattered throughout. The seeding of the legumes was thick in some spots and thin in others (see photos 4-5). We topped the weeds and legumes two more times before it was mowed for hay on September 3 and raked and baled on September 6. This approach to farm-grown nitrogen had to end here with the 94 bales of legume hay made and ready to be used as mulch for this next year.

<u>Second Approach to Farm-Grown Nitrogen</u>

In the meantime, I sought to modify a rear-discharge lawnmower to the side discharge and retrofit it with larger wheels. Once we looked into it, we found that buying a new mower was cheaper than retrofitting an old one, so we purchased a new one. This would be in readiness for cutting the in-garden alfalfa and red clover sown around the basil.

Potatoes and onions had been planted here in the 2000 growing season. Soil fertility for this garden plot had already been adjusted over the prior three growing seasons. However, "N" deficiency was still a problem as mentioned in the rationale for this experiment. In early May, I laid out the 90' by 6' plot, (see image file 3) keeping the long center 2' strip bare into which I would plant out 80 basil seedlings spaced 8" to 10" apart (see photos 6-9). The surrounding 2' on each side of the basil was seeded into legumes with a nurse crop of oats on May 7, one half of the plot (45') seeded with alfalfa and the other half with clover (45'), using the same seed varieties as in the 2 acre field. I watered the area immediately after seeding and throughout the season as needed. The basil seedlings were planted out June 8 even though it was still quite wet and cold. I used a row cover over them that I kept on for the rest of the season to prevent Japanese beetle damage (see image files 4 & 5).

On June 22, Tom Basden made a site visit to review the important aspects of soil sampling and in using the Pre-Sidedress Nitrogen Test (PSNT) and we took our first soil samples (see image file 6). We kept 3 basil plants as a control (A) in the alfalfa planting area and 3 as a control (C) in the clover planting area onto which no legume clippings were applied. Each week we ran the PSNT we had 4 samples—1) alfalfa, 2) control A, 3) clover, and 4) control C. We collected 4 data sets per week for 11 weeks total. The process followed for each PSNT was as follows:

Using a 6" soil probe, in Controls take 5 soil samples. In Clover and Alfalfa applications, take 10 soil samples, since they were much larger in size. Samples were placed into marked Ziploc plastic bags. Once collected, each sample was dumped separately into a bucket and mixed. Any organic matter and rocks were removed. A representative sample of each was then dried in a microwave oven to stabilize them. Then each sample was screened through a mesh colander. Finally, we proceeded with the actual PSNT, recording our readings from the Cardy Nitrate Meter in parts per million of N for each sample.

At the time of Mr. Basden's visit, he suggested I also do basil leaf petiole sap sampling on a weekly basis. This assay was not part of the grant request and cost only additional time yet gave a more accurate picture of N presence in the basil plants themselves. On July 13, Tom Basden made another site visit to oversee the protocol of the petiole sampling. We collected 4 data sets per week for 9 weeks total. The process for these was as follows:

Selected leaves with fully developed petioles about midway in the plant structure, not at the growing tip nor at the plant base, taking 10-15 leaves in each Control and 20-25 in Alfalfa and Clover applications. Each set of leaves was placed in a marked Ziploc bag and immediately put in a cooler with ice. Inside, the bags were taken out to reach room temperature; then petioles were cut from their leaves, roughly chopped and placed in a garlic press. A sampling sheet was placed on the expressed sap side of the press until saturated and then placed on the Cardy Nitrate Meter (see image file 7).

The legumes around the basil were cut three times--on June 25, July 14 and August 15. On June 25, because the basil plants were only 2-6" tall, I used the bagger to mow the legumes and applied the clippings around the basil by hand. I mowed with the wheels at their highest setting, resulting in a 4" high stand after mowing (see photos 11-16). I spread the clippings fairly evenly over the bare soil, simulating how the lawnmower would lay them down if I weren't bagging. The alfalfa clippings were almost double the volume of the clover as it was a thicker stand. I used only one lawnmower width of clippings on the soil around the basil each time. Even though it was a very dry day and I waited until late afternoon to mow, the clippings were very wet and were in subsequent cuttings as well.

On July 14, the basil was 10-16" high so I used the side discharge feature of the mower to make the 2nd cutting. On August 15, I made the last cutting and application using the bagger (see image files 8, 9, 9a & 9b).

One other element to this second approach to farm-grown nitrogen was seeding red clover between rows of sweet corn after its 3rd cultivation. On July 11, I seeded the red clover between the corn rows, weeding and watering as needed.

Findings and Accomplishments

For One Approach

I was unable to draw any conclusions about using the mulch hay since it was ready as the growing season came to an end. However, I'd like to make a few comments about the effort. The broad description above glosses over many gritty details which, for beginner farmers of whom I'd classify myself, are essential. First, having the right equipment is one those things. The need to make a roller was completely unforeseen but my creative husband had most of one fashioned the morning before he left for a two week vacation. I had to finish the detail of having a metal tongue made for it so I could pull it behind our Gator. We assumed we would be able to borrow a drop spreader for the colloidal phosphorus and a seeder to plant, the latter of which would've precluded the need to make a roller and to broadcast the seed. It is important to understand the subtleties of equipment and we did not. Of course, Mr. McConnell correctly steered us as we went but our stress level was very high until we understood how we were going to make do. This project not only increased our understanding of farming equipment but, in my opinion equally valuable, was coming to understand our farming community because now we know who is doing what and how.

Secondly, another essential detail for organic farmers in particular, was the difficulty in finding untreated oats. Clover and alfalfa were easy enough to find untreated (although deciding on pre-inoculated alfalfa was a bad decision – I'd find out later that this type of innoculant is genetically engineered). The "Ogle" var. oats I first purchased locally had to be returned when I found they were treated with Thiram and Rixal. The only alternative was to find oats intended as feed for animals. Although they may have had higher a weed content, they were untreated and germinated fine.

<u>For Second Approach</u>

The weekly PSNT results are attached in an Excel spreadsheet titled, "Basil Plot: Pre-Sidedress Nitrogen Test Data, Summer 2001." Using that data to determine the success of this experiment would, in my opinion, be weak. As you can see, the soil test results were rather flat, not showing dramatic changes even after a legume application. It does appear that the soil nitrogen levels built up from lows of 14 and 15 ppm in late June to highs of 24 and 25 ppm in late July to mid-August. Differences between the Clover and Alfalfa applications are inconclusive. The Controls didn't show much definitive difference either, varying only a little from the legume applications themselves. The data from the PSNT are just too flat to draw major conclusions.

However, there may be meaningful conclusions drawn from the petiole-sap sampling data in the Excel spreadsheet titled, "Basil Plot: Petiole Sap Sample Data, Summer 2001." Readings subsequent to 2 legume applications showed nitrogen increased in the basil plants 2 and 7 days after the wet legumes were applied. These increases were of a much greater magnitude in the Alfalfa application than the Clover. Furthermore, observations enhanced by my years of raising vegetables indicated that the basil plants had more nitrogen available to them than in previous years raising it at this farm. Sooner or later in the growing season the basil's deep green fades and takes on a yellowish cast. That's when I begin to apply fish emulsion to the foliage. I usually need 3 to 5 fish emulsion applications/season. This year I applied fish emulsion once, on Sept 8th, after

Basil Plot: Pre-Sidedress Nitrogen Test Data, Summer 2001

CUT	DATE	ALFALFA	CONTROL A	CLOVER	CONTROL C
	22-Jun	15ppm	15	19	15
25-Jun					
	29-Jun	18ppm	11	17	14
	6-Jul	16ppm	16	13	14
14-Jul	14-Jul	17ppm	16	17	16
	20-Jul	19ppm	17	16	17
	28-Jul	24ppm	23	25	22
	3-Aug	22ppm	24	23	20
	11-Aug	24ppm	23	23	20
15-Aug					
	17-Aug	15ppm	15	15	15
	24-Aug	missed			
	1-Sep	18ppm	15	19	15
	9-Sep	21ppm	19	18	19

Basil Plot: Petiole Sap Sample Data, Summer 2001

CUT	DATE	ALFALFA	CONTROL A	CLOVER	CONTROL C
25-Jun	13-Jul	420 ppm	140	500	550
14-Jul	20-Jul	690 ppm	180	500	600
	28-Jul	290 ppm	55	260	140
	3-Aug	130 ppm	53	230	120
	11-Aug	69 ppm	36	200	65
15-Aug	17-Aug	250 ppm	82	220	95
	24-Aug	82 ppm	65	110	65
	1-Sep	50 ppm	39	76	46
	8-Sep	62 ppm	43	64	48

petiole samples were taken that day. That in and of itself convinces me that we're onto something.

I liked the living legume mulch surrounding the basil because instead of fighting weeds and grass, the alfalfa and clover held their own and fixed nitrogen in the soil as well. Once we finally decide the legumes have come to the end of their usefulness, I'll turn them under, getting even more benefit from my previous labor and contribute to soil building. The legume plants themselves didn't seem to compete for water with the basil cash crop perhaps because they were not directly underneath. Growing the basil under row cover as I do can create a prime environment for weeds to gain an upper hand since one tends not to cultivate as often. The application of the legume clippings to the bare soil at the base of the basil plants helped with that by surpressing weeds although not totally eliminating them. Regarding water conservation benefits to the basil as a result of the clippings, I felt they weren't thick enough to have that effect. However, they were very wet on initial application and certainly didn't hinder the water cycle.

Regarding the side discharge of the clippings by the lawnmower, I found the application promising but problematic. On July 14, I used this mowing method since the basil plants were tall enough. However, the clippings shot out of the mower and hit the lower 5" of the basil plants. Five days later when I picked basil for restaurant sales, I found debris still on the lower leaves and a bit of decay as well where the legume matter still clung. Cutting with the bagger was easy enough to do but inefficient and could get quite time consuming since I had to then spread the clippings by hand. I believe the side discharge method could be refined and perfected and I've written another SARE grant in the hopes of doing that.

I have few conclusions about the red clover seeded between the rows of sweet corn. It was a battle to establish and it struggled against the purslane that periodically was quite thick although hand weeding helped. Finally, in early September, the clover was clearly established and greened up as the cooler weather came on. But because the corn season was over, I took no readings.

<u>Specific Affecting Conditions</u>

The wet spring definitely caused a delay in legume planting in the 2 acre field and is responsible for our late hay-making.

<u>Economic Findings</u>

The two forage sample analyses (see attached)-- one of a representative sample of the clover hay and one of a representative sample of the alfalfa hay – show a nitrogen content of 2.2%. Annualizing this year's establishment costs of $901.81 over five years (see Farm-Grown Nitrogen Costs, Flying Ewe Farm 2001 spreadsheet) gives $180.36. Adding that to the $103.40 for custom harvest equals $283.76. Our yield shows we had approximately 95 bales weighing on the average 23# each, giving 2185 total air dry weight harvested. When multiplied by percent total dry matter (average of 91%), we see that we garnered a total of 1988.35# of total dry matter. When multiplied by the 2.2% nitrogen analysis, 43.74 # of total nitrogen was grown. Dividing total annual costs of $283.76 by 43.74 # makes the cost per pound of nitrogen grown $6.49. This sounds high until one compares it to other common, but "store-bought" organic nitrogen amendments such as bloodmeal, alfalfa meal, and fishmeal. Bloodmeal comes closest to competing at a cost of $6.67 per #. Bloodmeal has low shipping and handling costs as it can always be found fairly locally. Costs per # of N for fishmeal and alfalfa meal were $12.56 and $29.62 respectively. The above prices were obtained from calculations using the 2002 Fedco Seeds (Waterville, ME) catalogue.

As our yield increases each year, our cost /# of N will decrease even with, for example, 3 custom harvests/year. If the 3 harvests garnered even a conservative 300 bales @ 30# average each, with the same total dry matter of 91% , we would have harvested 8190# of dry matter over that season. Based on 2.2% N again, the 180 # total nitrogen, when divided into $490.56 ($180.36 established cost annualized over 5 years plus 3 custom harvests) makes the cost of the N produced $2.72/#. Even at the higher cost of $6.49/# of N, it makes good sense to grow my own nitrogen this way.

Next Steps/Continuation

Because I have my own legume hay now, I am ready to measure how quickly and under what conditions there is nitrogen transferred to plants from legume hay applied under them. I have written another SARE grant to complete this under my acorn squash crop. I want to apply 3 different levels of mulch and determine the optimum amount by analyzing weekly chlorophyll meter readings. I am really excited about 1) having my own legume hay and 2) about this hay's potential as both a mulch and a nitrogen source. The establishment of the 2 acre hayfield has opened up so many possibilities for both long term soil fertility and short-term market crop plant health.

I also want to continue the other approach to last year's project in order to refine it and repeat results with the petiole sap sampling.

I plan on:

a) improving the legume clipping delivery method by designing and fabricating a funnel device to lay down material in a swath under and immediately next to the basil plants;
b) moving the controls away from any legumes (although they didn't receive any legume cutting application, the controls may have received some benefit from the nitrogen fixation in the soil from the legumes planted around them), and
c) and dropping the PSNT and using petiole sap sampling. A second year of data showing increased nitrogen levels after fresh-cut legumes are placed underneath the basil plants would corroborate our previous findings.

Outreach

Over the course of the spring and summer I gave presentations to a number of groups, describing the research experiment and showing the photographs. In June we hosted 25 individuals at our Spring 2001 Open House on farm, all of whom received a tour of the basil plot. In late July, I was one of the WV SARE grant recipients who described their Farmer-Grower grant projects at the 2001 Sustainable Fair in Buckhannon, WV. Approximately 40 people attended this event. In October, I taught a 3 hour class on organic gardening to the 8 Preston County Master Gardeners and county extension agent, during which I described my research project and passed around photos. I did not yet have the attached article called "Write a Farmer-Grower Grant!" to hand out but which I have since e-mailed to the agent and asked him to distribute. In November and December I also sent the article to the 50 some members of the WV Organic electronic discussion group; to the MSOGBA newsletter, The Organic Harvester (circulation of 130); to the national CSA newsletter, The Community Farm; to the national CSA-L discussion group; and to the WVU Sustainable Agriculture web page (see print out enclosed or see the active link at http://www.wvu.edu/~agexten/sustanag/grants/ssauter.htm). There were several other media mentions of my SARE grant, copies of which are enclosed:

- the Morgantown, WV Dominion Post announcing my grant award;
- an article about CSAs in the Oakland, MD The Republican and
- a printout from the web posting (or see active link at http://www.wvu.edu/%7Eexten/infores/newsrel/2001/010425-01.htm) of the original WVU Extension Service article about our CSA farm, the source for the latter article.

Susan Truxell Sauter

Susan Truxell Sauter
February 5, 2002

Dairy One
730 Warren Road, Ithaca, New York 14850 800-496-3344 Fax: 607-257-6808 www.DairyOne.com

Date: January 15, 2002

Samples: Hay

Carbon:Nitrogen Report

As-sampled basis

Sample	**4644580**	**4644590**
Description	Alfalfa 09/06/01	Clover 09/06/01
Nitrogen	2.2	2.2
Carbon	46.3	47.0
Organic Matter	83.35	84.52
C:N Ratio	78:1	108:1

DAIRY ONE

DHI Forage Testing Laboratory
730 Warren Road, Ithaca, NY 14850
800 496-3344 Fax: 607 257-1350

.909

DATE SAMPLED	LAB RECEIVED	DATE PRINTED	STATE	CO	FARM
01/05/02	01/14/02	01/14/02			

SAMPLE DESCRIPTION	FARM	CODE	LAB SAMPLE
LEGUME HAY		100	4644580

HARV 9-6-01 ALFALFA

ANALYSIS RESULTS

COMPONENTS	AS SAMPLED BASIS	DRY MATTER BASIS
% Moisture	9.1	
% Dry Matter	90.9	
% Crude Protein	13.6	14.9
% Ash	7.55	8.30
% Calcium	.98	1.08
% Phosphorus	.15	.16
% Magnesium	.17	.19
% Potassium	2.06	2.26
% Sodium	.004	.005
PPM Iron	268	295
PPM Zinc	35	39
PPM Copper	16	17
PPM Manganese	55	61
PPM Molybdenum	< 1	< 1

DAIRY ONE

DHI Forage Testing Laboratory
730 Warren Road, Ithaca, NY 14850
800 496-3344 Fax: 607 257-1350

.921

DATE SAMPLED	LAB RECEIVED	DATE PRINTED	STATE	CO	FARM
01/05/02	01/14/02	01/14/02			

SAMPLE DESCRIPTION	FARM	CODE	LAB SAMPLE
LEGUME HAY		100	4644590

HARV 9-6-01 CLOVER

ANALYSIS RESULTS

COMPONENTS	AS SAMPLED BASIS	DRY MATTER BASIS
% Moisture	7.9	
% Dry Matter	92.1	
% Crude Protein	13.9	15.1
% Ash	7.58	8.23
% Calcium	.94	1.02
% Phosphorus	.15	.17
% Magnesium	.17	.18
% Potassium	2.08	2.26
% Sodium	.002	.002
PPM Iron	227	247
PPM Zinc	33	36
PPM Copper	11	12
PPM Manganese	44	48
PPM Molybdenum	< 1	< 1

Farm-Grown Nitrogen Costs, Flying Ewe Farm 2001

Establishment Costs

Labor 1	$ 184.50
Labor 2	$ 288.00
Cover Oats	$ 12.00
Seed/ Alf	$ 49.50
Seed/Clov	$ 82.50
Shop work	$ 10.00
Innoculant	$ 11.20
Fertilizer	$ 262.21
Supplies	$ 1.90
	$ 901.81
Annualized by 5 yr.	$ 180.36

Annual costs

Establishment	$ 180.36
custom harvest	$ 103.40
	$ 283.76

Yield

no.	wt.	tot wt/airdry	tot DM	test %
95	23	2185	1988.35	.91%DM

% nit dry	2.2
lbs. total	43.7437
cost/ lbs	$ 6.49

Comparison	% Nit	Price(S/H)	Cost per lbs. of N
Bloodmeal	12	0.8	$6.67
Alfalfa meal	2.6	0.77	$29.62
Fishmeal	9	1.13	$12.56