Final Report for FNE02-438: Continuation and Refinement of Two Approaches to Farm-Grown Nitrogen

Goals Restated

As I explained in last year's SARE grant, 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 raise disturbing issues about 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.

Last year's work needed to be continued and refined—our dry, high nitrogen mulch hay wasn't ready to be used until the season was over. This year we were prepared to use it under our acorn squash to see how effective it would be in increasing yield and plant health. Furthermore, the fresh legume clipping approach to this the experiment needed refinement—a better delivery apparatus on the lawn mower, a control in a different location, and a second year of basil petiole sap sampling to corroborate last year's work.

Farm Info Updated

Since this project began, we've purchased nine more adjacent acres but our farming configuration remains the same. In 2002, we grew 14 mixed vegetable shares and just completed our fifth year of operating a CSA-type farm for which we have received our third year of certified organic status. We also expanded our marketing this year to include a restaurant and a farmer's market.

Collaborators and Their Roles

Our collaborators were Tom Basden, WVU Extension Specialist in nutrient management, Tom McConnell, WVU Extension Specialist in farm management, (Mr. McConnell also served as our Technical Advisor), and Dr. Sanjay Shah, Extension Specialist in agricultural engineering. All visited the farm once throughout the growing season at our request to help answer questions with our specific situation. Basden helped us think through the design of the acorn squash plot and walked us through operation of the SPAD meter. And when the first SPAD meter failed, Mr. Basden was instrumental in tracking down another so we didn't miss any readings. We consulted with McConnell on the hayfield, its health, and on the results of the dry forage tests. Dr. Shah and his graduate student designed and fabricated a baffle for the side discharge lawnmower on which we improved even further with actual use.

What We Did and How

One Approach to Farm Grown Nitrogen

In early June I laid out the acorn squash hills which were then mulched at different levels with legume hay harvested under last year's grant. Twelve hills were seeded with 3 – 6 seeds, each hill spaced 4 feet apart in one long row, after one 12 gal. bucket of composted horse manure was dumped atop each hill. One group

of three hills, Treatment 1, received 3 bales of nitrogen rich hay mulched in circles around each hill. Around Treatment 2, I placed 6 bales; around Treatment 3, I placed 9 bales. The volume of hay around Treatment 3 was a little challenging since it towered so high, but walking on it and subsequent weathering diminished its size. Average weight of the hay bales was 22 lb. each so Treatment 1 had 66 lb. hay; Treatment 2 had132 lb. hay; and Treatment 3 had 198 lb. of hay mulch applied. Of the remaining three hills, one served as the Reference (with 3- 6 plants) and two served as the Control (with 6-12 plants). As described in the grant, I had intended to have 3 hills each for the Reference and the Control but when planting I unintentionally planted too few hills and I discovered it too late to correct.

On June 30, we began the SPAD meter readings to get weekly reference numbers and to evaluate the different treatment effects. To help in this role, the Reference plants were given fish emulsion in a water solution at their base (vs. foliar) once a week, the theory being these would have all the nitrogen they ever needed, giving the largest SPAD reading against which to compare the other treatments. The SPAD number is not the chlorophyll per square inch but a reference number, i.e., the degree of light interception that occurs when the tool sends out two wavelengths of light that pass through the leaf and then arrive (or not) at the receptor unit. This number becomes one way to evaluate the treatment effect. Each week for 10 weeks, 12 readings were taken per treatment, choosing leaves in the mid-range of maturity—not end-of-vine leaves and not older base leaves. Values were then averaged by the SPAD meter for the weekly recorded reading. Because the Reference and Control had fewer plants, we took fewer readings to get their numbers--6 on the Reference and 10 on the Control plants.

Not necessarily relevant to the experiment, the acorn squash was grown under Covertan until late June when the crop needed pollination and the row cover was removed. We then began a twice weekly spray of Surround WP, a kaolin clay substance. When the plants were smaller, we used a sponge on leaves to dab away any Surround before taking SPAD readings. As plants matured, we didn't have to do this since we could find any number of vines that had grown 6 ft. since our previous SPAD reading and had no Surround on it yet.

Also, as part of this approach focusing on dry hay mulch, we made 2 cuttings of legume hay --once in June and again in mid August-- from the two acre hay field established with last year's grant, which garnered 136 bales and 109 bales respectively. We later had it analyzed for its nitrogen content to determine the economics of continued use of this N source in our market garden.

Second Approach to Farm-Grown Nitrogen

Simultaneously, we sought to improve the delivery method of the green legume clippings to our basil plants by first seeking out a non mulching blade for the lawn mower. Mr. Basden felt that our mower clogged last year because we had a mulching blade that minced up an already very wet cutting. This evidently is an unobtainable item for a new lawn mower such as ours. No store in the area carried a non mulching 21 in. blade for our mower so we had to take it to a small engine business where they cut a 22 in. non mulching blade to 21 in. This would be in readiness for cutting the in-garden alfalfa and red clover sown around the basil.

Acorn Squash: Chlorophyll Meter (SPAD) Readings & Yield: Summer 2002

as laid out in field

West DATE	Reference	CONTROL	Trtmt 1 3 bales	Trtmt 2 6 bales	Trtmt 3 9 bales	East	Highest Reading by week
30-Jun	36.4	37.5	38.5	41.9	40.36		Trtmt 2
8-Jul	41.8	40.7	43.1	41.8	42.2		Trtmt 1
17-Jul	41.3	40.6	45.2	44.7	43.9		Trtmt 1
21-Jul	40	37.6	39.7	39.8	39.7		Ref
28-Jul	41.2	38.9	39.1	39.6	40.6		Ref
4-Aug	37.9	36.7	39.3	40.2	39		Trtmt 2
11-Aug	35.5	33.7	37.4	40.5	44		Trtmt 3
18-Aug	39.4	35.6	37.8	42.1	41.7		Trtmt 2
25-Aug	35.4	35.3	38.4	39.1	41.5		Trtmt 3
1-Sep	34.8	31	34.3	36.6	39.9		Trtmt 3
YIELD	6.5# 1 hill	17.25# 2 hills	23.25# 3 hills	43.75# 3 hills	41.75# 3 hills		
Inferred 3-hill YIELD	19.5#	25.75#					

Basil Plot: Petiole Sap Sample Data, Summer 2002

CUT	DATE	ALFALFA	CLOVER	CONTROL
21-Jun				
	1-Jul	670 ppm	880	920
	8-Jul	370 ppm	460	700
	15-Jul	580 ppm	880	630
	21-Jul	370 ppm	880	510
29-Jul				
	28-Jul	590 ppm	1300	920
	4-Aug	910 ppm	1200	870
	11-Aug	480 ppm	1100	610
	18-Aug	250 ppm	340	330
	25-Aug	280 ppm	660	380
1-Sep				
	1-Sep	110 ppm	520	180
	8-Sep	190 ppm	200	200
	16-Sep	280 ppm	250	330
	23-Sep	360 ppm	330	570
	30-Sep	630 ppm	660	530
	6-Oct	570 ppm	360	300

Fine tuning this approach from last year also meant establishing a basil control at least 5 ft. away from the current basil legume patch. Soil tests showed P and K were adequate, so no soil amendments were necessary for the basil plots. On June 5 we planted out twelve basil plants which served as the Control, receiving no wet or dry clippings throughout the growing season, no fish emulsion, and no compost in the holes at planting time. On the same day, we set out our other basil plants into the center of last year's 90' by 6' established legume patch-- 41 plants at the red clover end and 41 plants at the alfalfa end—with the plants spaced 8" to 10" apart. (see photos 6-9 from 2001 Final Report)

In mid June Dr. Shah and Mr. Basden visited the farm to see the layout of the experiments and to consult on the redesign of the side discharge on the lawn mower. We agreed on a tentative design for it with an adjustable baffle protruding on the right side with suggestions made as to how it would be attached. Materials used for the baffle & its subsequent adjustments:

- 4 U-bolts with 4 wing nuts
- 10" x 34" galvanized sheet metal
- Two 2 ft. x ¾ in. galvanized electrical conduit
- Two ¼ x 1 ¼ inch hex bolts with nuts
- 21 in. x 6 inch aluminum flashing
- 12 sheet metal self-driving screws
- flat washers and lock washers
- pop rivets as needed

On June 21, the basil plants looked yellow and nutrient deprived. We made our first legume cutting using the baffle attachment. The legumes were 10-12 in. high. I mowed only one lawnmower width of clippings each time. The baffle still needed further adjusting as it allowed clippings to come out under it, hitting the small (6" high) basil plants even after we moved the baffle in from 4 in. to 2 in. so the clippings would shoot out farther away from the plants. The basil plants were damaged and we kept the row cover off the plants all day to assist in drying the clippings that had landed on the basil. We normally would put the row cover back on immediately to prevent damage from Japanese beetles. (Please see image on "How-to Fact Sheet" after further adjustments were made to the baffle.) The key adjustments made were to bring it closer to the ground by adding more galvanized metal and to double its length with a piece of aluminum flashing curved at the end.

On July 1, the basil plants were large enough (8 to 10 in. tall) to sustain leaf removal for their first petiole sap sampling and nitrogen recordings. Following last year's protocol, we made weekly readings (See Excel spreadsheet). We collected 3 data sets per week for 15 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 15 leaves in the Control and 15 in the Alfalfa and Clover applications respectively. 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 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 from 2001 report).

The legumes around the basil were cut three times--on June 21, July 29 and Sept. 1. Never did we apply fish emulsion to the plants which, before last year, is how we maintained basil plant health.

Findings and Accomplishments

First Approach Findings

The mulching itself of the acorn squash may have given the plants a boost, especially in Treatments 2 and 3. Because the hay was stacked so high initially, it may have created a mini microclimate around the emerging seedlings, warming them and protecting them from wind. Furthermore, moisture retention from the hay in a somewhat droughty year may have helped plant health. Treatments 1-3 had massive plants compared to the unmulched Reference and Control (See attached image). The heavy mulch also attracted wildlife—a snake and rabbit lived in Treatment 3 for some time--and squash bugs.

This experiment was not, however, intended to be about the effects of mulch but about the benefits from nitrogen in dry legume hay releasing to the plants. The weekly chlorophyll meter SPAD readings and acorn squash yield is noted in an Excel spreadsheet. Treatments 2 & 3 had the most frequent high readings (for three weeks each), most of those in the last month the acorn squash plants were alive. The other highest reading for Treatment 2 was in the first week. Again we suggest that the microclimate created by the hay the first week was the cause of that high reading and perhaps that nitrogen was finally reaching the plants the last month.

Acorn squash yield was highest for Treatment 2 at 43.75 lb. and next was Treatment 3 at 41.75 lb. If we infer a three-hill yield for the Control, it would have been next at 25.75 lb., followed by Treatment 1 at 23.25 lb. and lastly the Reference at an inferred three-hill yield of 19.5 lb. If this experiment were repeated, or any others were set up to determine cause and effect of various treatments on plants, I'd also evaluate the role of moisture—ranging from recording daily precipitation to, if possible, borrowing soil moisture meters or sensors to be used under the treatments. Something else to be considered for the long term would be a hay bale shredder, to improve mineralization in the treatments over the cropping year.

We forage tested our June and August cut hay, results of which are enclosed. Please see "Economic Findings" for a discussion. Note that nitrogen content was basically the same as last year at 2.2 percent.

Second Approach Findings

The final mower baffle attachment worked very well, laying down clippings immediately next to the basil plants and allowing me the ability to mow as close to them as I want--which is with the baffle practically touching them. With the new non mulching blade, the mower didn't clog for 2 out of the 3 cuttings. To circumvent the

Reference & Control End of Row

Treatment 3 End of Row

difficulties we had in getting a non mulching blade for our new mower, I'd suggest adapting an older lawnmower that more likely has this feature already.

Rain was scant and the alfalfa really struggled. Compared to the red clover, it had a difficult time competing with weeds, had sparse foliage, a bleached out appearance and leaf hoppers as well. The petiole leaf sample readings showed that the clover treatment consistently outperformed the alfalfa, the clover treatment having the highest readings 9 out of the fifteen weeks. Even the control outperformed the alfalfa, all but three weeks not having higher readings (see spreadsheet). By the second cut on July 29, the basil plants looked great with succulent and large leaves except for two plants in the alfalfa section which had very bright yellow blotches on them. These continued this appearance throughout the entire season. The blotches could possibly be from alfalfa mosaic virus that can be transferred to another crop by chopping and spreading infected material. This is a key bit of information I didn't have when I started this experiment two years ago and is another great reason to use red clover instead of alfalfa.

Drawing strong conclusions about the immediate effect of the wet legume applications in a dry year is difficult. It seemed that nitrogen became available to the plants when it rained--not necessarily the week when an application was made. We had rain the week of 7/28 when the numbers were some of the highest recorded. It wasn't until the next day, however, that we made a legume cutting and on 8/4, nearly a week after the wet clippings were applied, we see the numbers are still high but two of the values for the clover treatment and the control are actually a little lower than the previous week, reinforcing the idea that nitrogen became available as moisture was available. See previous comments regarding evaluation of moisture's role in future experiments.

Specific Affecting Conditions

As noted above, the dry conditions may have changed the experiment somewhat. In one approach, the dry mulch hay around the acorn benefited the health of the plants simply by virtue of moisture retention. In the second approach, the nitrogen may have become available to the plants when it rained--not necessarily the week when an application of wet legume clippings was made.

Economic Findings

The two sets of forage sample analyses (see attached)—one set each of alfalfa and of clover from the June 10 cutting and one set of alfalfa and clover from the August cutting--show nitrogen content of 2.2%. Using the annualized establishment costs (determined in last year's final report--see Farm-Grown Nitrogen Costs, Flying Ewe Farm 2002 spreadsheet) of $180.36 added to our 2002 custom harvest costs equals $418.56. Our yield shows we had 245 bales weighing on the average 23# each, giving 5635# total air dry weight harvested. When multiplied by percent total dry matter (average of 91%), we garner a total of 1988.35# of total dry matter (TDM). When TDM is multiplied by the 2.2% nitrogen analysis, it is determined that 112.81# of total nitrogen was grown. Dividing total 2002 costs of $418.56 by 112.81# figures the cost per pound of nitrogen grown is $3.71 (see price comparison to "store-bought" organic nitrogen amendments such as bloodmeal, alfalfa meal, and fishmeal, prices obtained from calculations using

as bloodmeal, alfalfa meal, and fishmeal, prices obtained from calculations using the 2002 Fedco Seeds, Waterville, ME, catalogue). Compared to our cost per pound of N at $6.49 in 2001, we see last year's conclusions being confirmed regarding our cost per # of N decreasing—and quite dramatically. Even figuring that we may have additional costs next year of reseeding the one acre of alfalfa with clover seed, it makes good economic sense to grow my own hay for a high nitrogen mulch.

With our 2002 cost per pound of nitrogen now determined, we figure that for Treatment 1 with 66 lb. of hay, at 91% DM, we applied 60.6# total dry weight (TDM), multiplied by 2.2% N equals 1.32 lb. of nitrogen at a cost of $4.90. Using the same formula, Treatment 2 with 132 lb. of hay, translates into 120 lb. TDM, equaling 2.64 lb. nitrogen at a cost of $9.79. Treatment 3 with 198 lb. of hay mulch becomes 144 lb. TDM, equaling 4 lb. nitrogen applied at a cost of $14.83.

Next Steps/Continuation

As I said last year, the establishment of the 2 acre hayfield opened up so many possibilities for both long term soil fertility and short-term market crop plant health. I would like to make the entire 6-acre field into a legume hayfield. This will depend on whether haymaking equipment is available in the future—area farmers are selling off their equipment and it doesn't make sense to buy our own for such a small acreage. If equipment will be available for the next few years, I want to both overseed the 1-acre alfalfa with clover because the clover competed much better with the weeds and seed the rest of the surrounding field so I'll continue to have legume hay for use in my market garden.

I also will continue the other approach of growing legumes in the market garden so that fresh-cut legumes can be placed underneath the basil crop and possibly other vegetable crops--except I will drop the use of alfalfa for reasons stated previously. Because our small market garden is farmed so intensively, we don't have as much flexibility for "fallow time" or down time to rebuild soil nutrients. This approach to the experiment designed soil fertility building into the market season in conjunction with the growing of the market crop—a feature I really appreciate and something I didn't necessarily anticipate when conceiving the idea.

Outreach

Over the course of the year I gave presentations to a number of groups to whom I either mentioned or described SARE and/or my research experiment.

- February 22 "E (Environmental) Day", West Virginia State Capitol Rotunda, Charleston, West Virginia, hundreds attended overall event
- March 13 Fruit School, WVU Extension, Kearneysville, West Virginia, 75 in attendance
- March 14 Fruit School, WVU Extension, Romney, West Virginia, 30 in attendance
- April 15 Parent's Place, Morgantown, West Virginia, 25 in attendance
- May 7 Master Gardener class, WVU Extension—Preston County, Kingwood, West Virginia, 8 in attendance
- September 13-14 North Preston Farmers Club Fall Festival, Bruceton Mills, West Virginia, hundreds attended overall event

- October 14 Mountain People's Food Co-op, Morgantown, West Virginia, 11 in attendance
- November 6 Master Gardeners, WVU Extension--Monongalia County, Morgantown, West Virginia, 18 in attendance

Because of health problems this year, we didn't have an Open House as expected but I made a concerted effort to spread the word about SARE and my project at every event at which I was asked to speak. Please see the attached article called "How-to Fact Sheet for Two Approaches to Farm-Grown Nitrogen" detailing my project. Also please see additional publicity from last year's article called "Write a Farmer-Grower Grant!" which continued to make its way into various media venues in 2002:

- The Natural Farmer
- The Community Farm (printout of e-mail version)

The WV Organic electronic discussion group no longer exists and the MSOGBA newsletter, The Organic Harvester hasn't had an editor for half a year. I submitted my 2002 article to the national CSA newsletter, The Community Farm; to the national CSA-L discussion group; and asked for it to be posted to the WVU Sustainable Agriculture web page.

Susan Truxell Sauter
January 2003

Farm-Grown Nitrogen Costs, Flying Ewe Farm 2002

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	$	238.20
	$	418.56

Yield

no.	wt.	tot wt/airdry	tot DM	test %
245	23	5635	5127.85	.91%DM

% nit dry		2.2
lbs. total		112.8127
cost/ lbs	$	3.71

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