Farmer Rancher Grant Program

Final Report Form

Please fill out the final report form and return it to the North Central Region-Sustainable Agriculture Research and Education (NCR-SARE) Missouri office. The report may be prepared on a computer or handwritten (please write or print clearly) but electronic reports are preferred. The final payment of your grant will be awarded when the final report and final budget report are received and approved.

Use as much space as needed to answer questions. You are not limited to the space on this form. The more details the better.

I. PROJECT IDENTIFICATION

- Name: Karen Weiss- Little Foot Farm
- Address: 13575 40th St S
- City, State, Zip Code: Afton, MN 55001

- Phone: 612-207-9771
- Website: www.littlefootfarm.com

Project Title: ***"Creating a Sustainable Year-Round Greenhouse Cropping System Using Straw-bale Culture and LED Lighting."***

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- Project Number: FNCC09-747
- Project Duration: 2 years
- Date of Report: 3/22/2012

II. PROJECT BACKGROUND

1. Briefly describe your operation (i.e. how many acres, what crops, types of cropping systems, type of livestock or dairy production, grazing systems, family operation, etc.)

Little Foot Farm is a 35 acre farm that has 3 main enterprises: seasonal greenhouse business, perennial fruits and vegetables, and heritage breed pasture hogs. We manage all operations with an emphasis on sustainable and conscientious growing methods. We employ one part time staff person. Most of our sales are direct marketed from the farm.

2. Before receiving this grant, did you carry out any sustainable practices? If so, briefly describe what they were and how long you had been practicing them.

We have always employed sustainable practices for all of our operations. We grow all of our own greenhouse product, use bio-degradable containers, soy based fertilizers and organic products for pest and disease control. We do not use pesticides or herbicides on our fruits and

vegetables and manage our hogs and chickens using Animal Welfare Institute standards.

III. PROJECT DESCRIPTION

This is the core of the report. Consider what questions your neighbors or other farmers or ranchers would ask about what you did with this grant. Describe how you planned and conducted your research or education activities to meet your project goals and discuss the results.

GOALS

List your project goal(s) as identified in your grant application.

The goal of this project was to create and evaluate a year-round growing system that could utilize the traditionally dormant greenhouse seasons. The use of LED lighting and straw-bale culture was chosen as an alternative to traditional forms of greenhouse season extension such as plastic containers or in-ground growing, in an effort to minimize energy inputs and maximize cropping flexibility.

PROCESS

Describe the steps involved in conducting the project and the logic behind the choices you made. Please be specific so that other farmers and ranchers can consider what would apply to their operations and gain from your experience.

Layout and Schedule. The first task was to design the layout of the straw bales to create as much growing area as possible (230 sq. feet) in the greenhouse. See Attachment #1 as an example of our winter layout. We also wanted to establish a cropping schedule the would allow for 3 Phases to be completed in a calendar year. Phase 1 would be June 1-October 15. Phase 2 would be a short season of Nov. 1- Jan.1. Phase 3 would be Jan. 15- May 15.

Establishing growing media to use on straw bales. We wanted to determine the best topdressing medium so that we could replicate year over year and have a baseline for making adjustments and controlling variables. The greenhouse was divided into two sections. In Phase 1, on Side A we used straight compost and on Side B we used Sunshine Organic Potting Mix and Sustane fertilizer. In Phase 2 and 3, bales on Side A were top dressed with Sunshine Natural & Organic Planting Mix and Paramount Green Pure Natural Organic Worm Castings while bales on Side B were top dressed with Sunshine Natural & Organic Planting Mix and Sustane Fertilizer. See Attachment #1 and #2

Lighting. For Phase 1 (June-Oct15) we did not use supplemental lighting as day-length and light intensity was sufficient. In Phase 2, (Nov. 1-Jan.1) 25 Red, 220 diode, LED lights were arranged above the bales so that each light covered approximately 2 bales. The light came on at 3 pm and went off at 9 pm to create a total of 14 hours of light in the greenhouse (8 hours natural daylight and 6 hours LED lights). For Phase 3 (Jan 15-April 15) we focused on a more rigorous research process to determine the effects of different lighting treatments on the crop. The greenhouse was arranged so that we could apply 3 different lighting treatments with 4

replication for each treatment. The treatments were: 4 red LED lights only; 2 full spectrum/blue LED and 3 red LED lights; and no LED lights. Mark Fleck, an LED expert with Grow with LEDs, was consulted to discuss the various treatment options. The lights come at 4am and turn off at 12 am for a total of 20 hrs of supplemental lighting. We chose this maximum amount of lighting based on previous research and the desire to maximize the differences in lighting treatments vs. no lighting.

Crops. A variety of crops were grown through the 3 Phases year 1. The Phase 1 (summer) trial included tomatoes, peppers and strawberries. The Phase 2 (fall/winter) crops included lettuce, arugula, carrots, beets, sugar snap peas, radishes, spinach and tatsoi. The Phase 3 (winter/spring) crop is exclusively sugar snap peas.

In year 2 we focused on just the crops that we felt had the potential to be economically viable so we grew sweet peppers during Phase 1 and sugar snap peas in Phase 2. We decided that heating the greenhouse in January and February was too economically risky regardless of the cop we chose, so we would limit non-bedding plant production to just summer thru late fall.

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PEOPLE

List farmers, ranchers, or business people who assisted with the project and explain how they were involved. List any personnel from a public agency, such as the Extension Service, Natural Resources Conservation Services or Soil and Water Conservation Districts who assisted with this project. List people from non-profit organizations who helped you.

We received guidance from Prof. Bud Markhart as to both crop options for marketability, Mark Fleck for advise on LED lighting options and produce managers from both Mississippi market and the Wedge for guidance on pricing strategies and marketability of "out of season" or "first to market" products

RESULTS

What results did you achieve and how were they measured? For production projects, include yields, field analysis, and related data. How do these compare with conventional systems used previously? For education projects, include outcomes achieved and how you measured them through surveys, attendance, or other methods. Were these results what you expected? If not, why not? What would you do differently next time?

(During the course of this project, I determined that the use of LED supplemental lighting as an input for the "out of season" production of sugar snap peas, was worthy of more detailed study. In doing so, I dovetailed my Masters Integrated Project with this SARE project. I presented the finding in a public forum in December of 2011 at the University of Minnesota. I have attached the full research project and slide presentation.)

Straw bales. While we began lying the bales with stings up, we eventually placed bales on their edges with the strings on the sides. With the twine on top, there was more degrading so that when bales had to be moved the twine would often break and replacement bales or re-enforcement of some kind such as rebar pounded into the ground was required. This did influence moisture retention as water more easily penetrated through the bales oriented in this manner. Another drawback of placing the bales on their sides is that it reduced the growing area, thus requiring more straw bales per square foot. Despite these issues, for the most part we were able to use the bales for two phases and determined that bales placed on edge was preferred.

Media/top dressing. It was determined that there were no noticeable differences in germination results or plant growth between the different topdressing treatments. The top dressing chosen going forward will be based on what is most cost effective for the season. Most likely compost during the summer and bagged when compost is not available. We will use Daniels Plant Food, a natural soy based fertilizer in conjunction with Sustane. We determined that fertility using just Sustane as a side-dressing in the bell peppers was not adequate. We will supplement with Danials Plant Food, a water soluble fertilizer in every other watering for both peppers and sugar snap peas.

Environmental Conditions. The straw bales did not break down or compost enough to create any significant root zone heat for the plants. Greenhouse heat retention was improved by approximately 3F when an inner cover was used. We maintained a minimum night temperature of 40F during the winter months. Our biggest challenge however, was controlling moles and mice in the greenhouse during all season. These rodents seek shelter in the straw bales and damage a number of crops in both early and late stages of growth. We have decided that rather than fight the mice and moles we will focus on growing crop that so far have not been appealing to them. Despite not being certified, our organic approach makes the controlling of rodents very difficult.

Summer Crop- Year 1

. Tomatoes had a lot of vegetative growth but not a lot of fruit. One remedy may be to pollinate the tomatoes in the greenhouse. Another issue with the tomatoes is that a taller structure is needed to accommodate the height growth of the tomato plants grown on a raised bale. We also lost a lot of tomatoes to mice and moles that seek shelter in the greenhouse and straw bales. We observed that strawberries could be a potential crop, but damage by mice and moles would have to be overcome in order to make it a viable summer crop.

Summer Crop- Year 2

Peppers were our best summer crop both in growth and in yield. averaging .5lbs and yielding 3 lbs per linear foot of bales. We had no disease or pest pressure. The mice and mole did not bother the peppers and we were able to harvest an average of 4 peppers per plant without sun scald or blossom end rot both of which were encountered in our outdoor plantings. We learned that using water soluble Daniels Plant Food, a natural soy based fertilizer in conjunction with Sustane as a side dressing provided the best results. We also learned that the peppers need to be well established before the sever summer heat sets in. Peppers (2" liner transplants) planted on June 15 faired much better than those planted on

July 1. We also learned that staking was very helpful for peppers grow in bales as the looseness of the medium doesn't allow for great anchoring. A summary of our final pepper planting is represented below.

Expense Item	Number of Units	Cost /unit	Total Cost	Cost/Crop
Bales	24	$ 2.50	$ 60.00	$ 30.00
Soil	(6)2.8 cu ft bags	$ 11.00	$ 66.00	$ 49.50
Seeds	1/2 lb/1000 sds	$ 6.50	$ 3.25	$ 3.25
Fertilizer	6 lbs	$ 1.20	$ 7.20	$ 7.20
Electricity	0	$ -	$ -	$ -
Nat. Gas	0	$ -	$ -	$ -
LED 60 diode Full Spectrum	0	$ -	$ -	$ -
LED 200 diode Red Spectrum	0	$ -	$ -	$ -
Labor (hrs)	8	$ 8.00	$ 64.00	$ 64.00
			Total	**$ 153.95**
Income	**yield in lbs**			
lbs.peppers harvested in summer 2011	40	$ 2.00	$ 80.00	$ 80.00
Net Profit (Loss)				**$ (73.95)**

This yield represents a 14' row of peppers that were transplanted on June 15. These peppers were harvested over a 6 week period from September 2 to October 7, consistently producing between 6 and 8lb per harvest. We had a frost on September 14 and 15 that probably would have damaged any remaining field planted peppers. Whereas the small number of garden planted peppers suffered from sun scald and blossom end rot, no disease damage was found on the greenhouse grown peppers. The remaining 46' were transplanted on July 1, but did not produce market quality peppers. The 100°F temperatures during the early part of July really set these plants back and they never fully recovered. The plants were small and the peppers they produced were also small and misshapen. If all rows had been planted in mid June and been successfully grown to harvest a yield or 160 lb and a profit of approximately 167.00 or $.75/sq. ft of greenhouse space. Going forward we will transplant peppers from 4" containers, by June 15 so that harvest can start 2-4 weeks earlier.

Fall/Winter Crop-Year 1. Due to either poor germination, predation or excessively slow growth, it was determined that most of the winter crops would not be carried forward after year 1. Spinach, however was the exception. Spinach had no observed injury due to predators in the greenhouse, germinated in a close and short window, was ready to harvest in less than 60 days, and had an excellent sweet and mild flavor. The spinach also grew well without any apparent sensitivity to the amount of light in the greenhouse. We hope to interplant spinach with sugar snap peas for in our next late summer planting.

Winter/Spring Crop- Year 1 and 2. Based on our first year Phase 2 results, we chose to focus on sugar snap peas for Phase 3. As a high value crop that utilizes the vertical space in the greenhouse, does not need outside pollination and can be grown at reasonably cools temperatures it presented us with a very appealing crop option. As such, we began a detailed research project to identify the best lighting options for sugar snap peas. The finding

from this component of our project were detailed in a Masters of Agriculture in Horticulture Integrated Project. A summary of the results are included in the table below.

Expense Item	Number of Units	Cost /unit	Total Cost	Cost/Crop	Cost/Sq Ft/Crop
Bales	24	$ 2.50	$ 60.00	$ 30.00	$ 0.13
Soil	(6)2.8 cu ft bags	$ 11.00	$ 66.00	$ 49.50	$ 0.21
Seeds	1/2 lb/1000 sds	$ 6.50	$ 3.25	$ 3.25	$ 0.01
Fertilizer	6 lbs	$ 1.20	$ 7.20	$ 7.20	$ 0.03
Electricity	468 kWh	$ 0.10	$ 49.00	$ 49.00	$ 0.20
Nat. Gas	180 therms	$ 0.71	$ 127.80	$ 127.80	$ 0.53
LED 60 diode Full Spectrum	8	$ 24.00	$ 192.00	$ 6.00	$ 0.03
LED 200 diode Red Spectrum	28	$ 68.00	$ 1,904.00	$ 60.00	$ 0.25
Labor	16 hrs	$ 8.00	$ 128.00	$ 128.00	$ 0.53
			Total	**$ 460.75**	**$ 1.91**
Income					
Sugar Snap Peas Harvested-Spring 2011	9lbs	$ 6.00	$ 54.00	**$ 54.00**	**$ 0.23**
Net Profit (Loss)				**$ (406.75)**	**$ (1.68)**

Future Work/Changes Some possible changes that effect energy inputs might include: planting in peas in mid-September, thereby heating and lighting on the backside of crop time-reducing heating cost and maximizing lighting efficiency (while this timing would not provide a 'first to market' advantage, it would provide an out of season advantage); reducing the hours of lighting per day and/or increasing the coverage area by raising the initial lighting set-up; and finally, altering the minimum night time temperature to reduce heating cost or reduce the crop time.

In conjunction with the above possible changes, yields may be influenced by ; taking proactive measure to limit the risk of disease, monitoring for micro nutrient deficiencies and/or by altering planting density to maximize space, especially if horizontal airflow fans (HAF) are used. Based on an average of the 4 highest yielding blocks in our second sugar snap pea planting of .5 lbs./ lf (with high disease pressure), if bales were run lengthwise and plants were not spaced to separate blocks, it is conceivable that the same greenhouse space could support 60 lf rather than 30 lf. For this layout, there would be 720 total plants and 30 total lights equaling 260 watts. In this scenario, the same space yielding .5lb/lf, could have yielded a total of 30 lbs. of edible pea pods. At $6.00/lb, a loss of $114 would have occurred. Table 2. reflects hypothetical expenses based on Dec 5, 2011 LED cost per light, a 2 ft light spacing, a 70 day growing period requiring approximately 30 days of supplemental light and heat, 10 hours of supplemental lighting, 60 lf of planting and .5 lb/lf yield. These alterations reduce the heating and lighting inputs to just over one third of total expenses. If disease pressure was managed and yields of **.2lb/plant** (a typical amount for field grown sugar snap peas) were achieved, a yield of 144 lb and a profit of $570.00 could be realized. While strictly speculative, it is believed that these scenarios do offer enough incentive to warrant additional cropping attempts.

Expense Item	Number of Units	Cost / ur	Total Cost	Cost Per Cr	Cost/Sq Ft/Crop
Bales	24	$ 2.50	$ 60.00	$ 30.00	$ 0.13
Seeds	1/2 lb/1000 sds	$ 6.50	$ 4.87	$ 4.87	$ 0.02
Soil + Compost	(6)2.8 cu ft bags	$ 11.00	$ 66.00	$ 33.00	$ 0.14
Fertilizer	6 lbs	$ 1.20	$ 7.20	$ 7.20	$ 0.03
Electricity	116 kWh	$ 0.10	$ 12.06	$ 12.06	$ 0.05
Nat. Gas	80 therms	$ 0.71	$ 56.80	$ 56.80	$ 0.24
LED 90 diode Full Spectrum-**2011**	10	$ 20.00	$ 200.00	$ 6.25	$ 0.03
LED 200 diode Red Spectrum-**2011**	20	$ 54.00	$ 1,080.00	$ 33.75	$ 0.14
Labor	14 hrs	$ 8.00	$ 112.00	$ 112.00	$ 0.47
			Total	**$ 295.93**	**$ 1.24**
Income					
Sugar Snap Peas Harvested-Scenario #1	.5lb/ft =30lbs	$ 6.00	$ 180.00	$ 180.00	$ 0.75
Net Profit /Loss				**$ (114.31)**	**$ (0.49)**
Sugar Snap Peas Harvested-Scenario #2	.2lb/plant=144lbs	$ 6.00	$ 864.00	$ 864.99	$3.60
Net Profit /Loss				**$570.68**	**$2.36**

Table 2. Hypothetical Expense Report- Fall Grown Sugar Snap Peas 2012- 224 sq. ft Greenhouse space

We replaced out small greenhouse this past fall and were not able to plant sugar snap peas in the fall season. We have however, doubled our LED lighting and will use what we learned from the previous two years begin a pepper -pea rotation this year. Peppers have been seeded and will be transplanted on June 15 from 4" containers rather than 2" liners. We plan to follow with peas by September 15th. We hope the fall planting will allow for harvest to be completed by Dec. 1.

DISCUSSION

What did you learn from this grant? How has this affected your farm or ranch operation? Did you overcome your identified barrier, and if so, how? What are the advantages and disadvantages of implementing a project such as yours? If asked for more information or a recommendation concerning what you examined in this project, what would you tell other farmers or ranchers?

One of the most important things we learned from this project was that if the scale of the production isn't big enough to produce a meaningful income, then it isn't worth the management time to carry it forward unless a passion for the product is an underlying factor. Even though we are a small operation that relies on diversity and multiple income streams, the opportunity cost of our time to manage an enterprise isn't just measured in hours of labor. If we can't reasonably scale something to produce a profit in the thousands of dollars rather than hundreds of dollars there has to be a real passion for the product.

We will in all likelihood approach the use of straw-bales in a different way. As we grow our hog operation and have straw from winter deep bedding, the production of compost has taken on a larger scale. The seasonal timing of straw removal from our hog hoop building may offer the opportunity to "hold" the straw for the late spring thru fall in a greenhouse set-up for the production of peppers and sugar snap peas. I have designed a greenhouse bench

that would serve as framing to hold the composting straw bedding pack. This would save the cost of bales for growing and would still produce compost after growing to apply in our orchard.

We also learned that in a typical winter, like the one we had in 2010-2011, the cost of heating the greenhouse mid-December thru mid-February makes producing a profitable crop difficult. Because we have an established use for the greenhouse in spring, we could not justify the risk involved to try to produce a winter crop that would potentially have a low yield, or a high cost due to heating requirements. We do, however, feel that the additional 2 seasons of greenhouse use is a worthwhile use of this resource.

The use of straw-bales as a growing medium has pros and cons. On the positive side, they do allow flexibility, they offer a raised bed that makes many growing tasks easier, weeding is minimal and when required, easier than in the ground weeding and they can be recycled. The main negative features were the difficulty in moving them once used and the habitat that they created for moles. Because we used a greenhouse that had polycarbonate end wall and a 36" door, we had to move the bales manually. We put up a larger open ended greenhouse this past fall that will allow for tractor access and a much easier means to move straw in and out. To solve the mole and mice issue, we will focus on two crops that seem to not be of interest to moles and mice.

The use of LED lighting also had its pros and cons. Stringing the lights in an economical manner was labor intensive. Because LEDs have a narrow lighting arc and low light output per bulb, they have to be positioned close to the plant canopy. This required adjustments both between crops and during crop production. We hope to limit this issue with sugar snap peas by growing them in the fall when their lighting requirements will increase as the plant grows thus lessening the need for lighting until the plants have reached a height where the lighting can be hung in a fixed location. Also the cost of LEDs has come down over 20% since we purchased them, making their use more economically viable. If costs continue to come down, utilizing them for season extension, will become much more viable. As our research established, they are effective as a grow light.

We also learned that it is difficult to grow specific high value crops in a window that allows multiple seasons of use. If we can get peppers grown and harvested by September 10 and get pea seedlings in by September 15th, we might be able to manage both of these crops successfully. We could conceivably be "first to market" with peppers sold direct from the farm as apples begin to come in, while selling peas to co-ops during an "out of season" timeframe there by getting a premium price.

IV. PROJECT IMPACTS

Evaluate the economic, environmental and social impacts of this sustainable practice by completing the Benefits and Impacts form. Also, if possible, provide hard economic data.

V. OUTREACH

What methods did you use for telling others about: 1. Your project, 2. Project events or activities, 3. Project results? How and to whom did you communicate this information? Be sure to include

details on how many people attended field days or demonstrations, and how information was further disseminated by media covering any events. What plans do you have for further communicating your results? Include press releases, news clippings, flyers, brochures, or publications developed during this project. Also include photos which might be helpful in telling your story to others. (Mail items separately if you cannot send them electronically.)

In the spring of 2011, I gave an in house field trip presentation to St. Ambrose ECEC in Woodbury. We had 3 separate sessions with about 40 students attending each session. The focus was on edible pea pods and making the connection from seed to plant to pod. The kids all snacked on freshly harvested pea pods and did a pea germination experiment in their classrooms.

In December of 2011 I presented much of the what I learned from this project through a Masters of Agriculture in Horticulture Integrated Project presentation. There were approximately 40 students and faculty from the University of Minnesota in attendance.

VI. PROGRAM EVALUATION

This was the nineteenth year the North Central Region SARE Program sponsored a farmer rancher grant program. As a participant, do you have any recommendations to the regional Administrative Council about this program? Is there anything you would like to see changed? Please fill out the Evaluation form.

VII. BUDGET SUMMARY

Complete the final budget form and return it with your report. You will only be reimbursed for expenses incurred and items purchased for conducting your project. If you made significant changes to final expenses listed by budget category (more than 10% of your grant total or $1,000 – whichever is higher), please include an explanation for the changes. Call Joan Benjamin with questions at: 573-681-5545.

Submit your final report to:

E-mail: BenjaminJ@lincolnu.edu or mail to:
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