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Harvest the Sun, Build the Soil

Chandler Bane
Iowa State University, cabane@iastate.edu

Mitchell Hora
Iowa State University, mhora@iastate.edu

Gabe Lorack
Iowa State University, glorack@iastate.edu

Nick Lane
Iowa State University, nrlane@iastate.edu

Joseph R. Vanstrom
Iowa State University, vanstrom@iastate.edu

See next page for additional authors

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Harvest the Sun, Build the Soil

Problem Statement

Can altered methods within modern day production agriculture be used to better utilize sunlight, increase yields, and improve farm economics while improving environmental sustainability? Cedar Valley Innovation is a one-person entity, but utilizes information from a vast network of individuals within the industry. Utilizing information from stakeholders and customers, Mr. Recker has gained a lot of additional knowledge aimed at advancing agriculture practices. Mr. Recker has developed connections with farmers/growers across the nation. Our team has analyzed yield from Mr. Recker's small plot scale. Our client also recommended that we analyze yield and overall economics of a new farming practice on a large scale. At this point, we are still not convinced that farmers will be able to change the overall structure of traditional farming formats. In each project that Mr. Recker takes on his goal is to leave his personal legacy on modern agriculture. According to our calculations, we found that the proposed practices will cause a loss of overall field yield and yearly income. However, with more research, Mr. Recker can continue developing the "Sunlight Harvest Strips" field formation. Environmental issues dealing with water quality and sustainability are hot topics. "Sunlight Harvest Strips" show promise in their ability to reduce nutrient loss to the water system. By continuing a partnership with Dr. Kaleita, of the ABE Department, Mr. Recker can move forward with the environmental effects of new farming methods.

Disciplines

Bioresource and Agricultural Engineering | Industrial Technology

Authors

Chandler Bane, Mitchell Hora, Gabe Lorack, Nick Lane, Joseph R. Vanstrom, and Jacek A. Koziel

Department of Agricultural and Biosystems Engineering (ABE)

TSM 416 Technology Capstone Project

Harvest the Sun, Build the Soil

Chandler Bane[a], Mitchell Hora[b], Gabe Lorack[c], Nick Lane[d], Joseph R. Vanstrom [e*] and Jacek A. Koziel [f*]

[a] Agricultural Systems Technology, ABE, ISU, cabane@iastate.edu
Agricultural Systems Technology, ABE, ISU, mhora@iastate.edu
[c] Agricultural Systems Technology, ABE, ISU, glorack@iastate.edu
[d] Agricultural Systems Technology, ABE, ISU, nrlane@iastate.edu
[e] Dept. of Agricultural and Biosystems Engineering, ISU, 2321 Elings Hall, Ames, IA 50011, vanstrom@iastate.edu, 515-294-9955
[f] Dept. of Agricultural and Biosystems Engineering, ISU, 4350 Elings Hall, Ames, IA 50011, koziel@iastate.edu, 515-294-4206

*course instructors and corresponding authors.

Client: Cedar Valley Innovation, 116 W Schrock Rd, Waterloo, IA, 50701

- Contact(s): Robert Recker, Owner, cedarvalleyinnovation@gmail.com, (319) 240-2200

1 PROBLEM STATEMENT

Can altered methods within modern day production agriculture be used to better utilize sunlight, increase yields, and improve farm economics while improving environmental sustainability?

- Cedar Valley Innovation is a one-person entity, but utilizes information from a vast network of individuals within the industry. Utilizing information from stakeholders and customers, Mr. Recker has gained a lot of additional knowledge aimed at advancing agriculture practices. Mr. Recker has developed connections with farmers/growers across the nation.
- Our team has analyzed yield from Mr. Recker's small plot scale. Our client also recommended that we analyze yield and overall economics of a new farming practice on a large scale.
- At this point, we are still not convinced that farmers will be able to change the overall structure of traditional farming formats. In each project that Mr. Recker takes on his goal is to leave his personal legacy on modern agriculture. According to our calculations, we found that the proposed practices will cause a loss of overall field yield and yearly income. However, with more research, Mr. Recker can continue developing the "Sunlight Harvest Strips" field formation.
- Environmental issues dealing with water quality and sustainability are hot topics. "Sunlight Harvest Strips" show promise in their ability to reduce nutrient loss to the water system. By continuing a partnership with Dr. Kaleita, of the ABE Department, Mr. Recker can move forward with the environmental effects of new farming methods.

Business Case Statement - With a growing global population, there is a continued need for more food. However, in the US, agricultural land is decreasing and sustainability issues are pushing regulations on agriculturalists.

A. Current agricultural practices continue to improve but solving problems 10 years from now will bring a lot of change. There is an ever growing need for improved yields, environmental sustainability, and economic advancement.
B. The root problem encompasses the entire planet, however, implementing new practices will bring about many farmer specific concerns.
C. Food security is a global issue and improvements must be made in a sustainable manner.
D. Our client wanted to see what needs done in order to implement such an abstract idea. The opportunities are huge because implementing new practices can address many issues.
E. Everyone cares about food security but a big proponent of this change will address governmental concerns with sustainability and water quality. There is potential for better farm subsidies and security against regulations if on-farm benefits can be made.

2 GOAL STATEMENT

Our Goal was to challenge the standard ideas of traditional production agriculture by researching this specific alternative in order to determine if this proposed change may make a difference in production agriculture.

A. The fundamental "root cause" was whether leaving strips between corn rows will be paid for by the increase in yield from said corn.
B. Utilizing yield data and other data gathered from several test plots, we determined if the increase in corn yield with additional sunlight exposure will pay for the rows that are not planted.
C. Questions
    - What was the highest yielding ratio of empty rows to high yielding rows?
    - What was the potential farmer adaptation rate?
    - Was the proposed method beneficial or harmful for farmers?
    - What research needs done in order to adopt a harvest strip system?

The main objective of this project was to perform extensive research on the data that was provided by Cedar Valley Innovation, while referencing our TSM class materials and addressing growers' concerns, to determine if implementing "Sunlight Harvest Strips" is profitable on a large scale. The specific objectives that Mr. Recker was inquiring us to complete are outlined below. Accomplishing these objectives gave us the necessary information to present the final project to Mr. Recker with aspects that met and exceeded the main objective.

- Clear statement of projected yield results from these practices.
- Clear statement of how economic return changes with these practices.
- Listing the issues or missing information that growers want to see before adopting a new practice.
- Recommendations for activities that would address the concerns identified above.

Constraints

This project encompassed a lot of moving parts regarding the incorporation of strip cropping into a farmer's operation. Some things had the possibility to severely limit a farmer's capability of adopting this practice and obtaining some sort of benefit or profit. A few constraints that we encountered and needed to consider when presenting this project were:

- Economic implications
- Equipment specifications and dimensions
- Farmers' attitudes towards removing rows
- Differing landscapes and topography

Rationale

There are currently several specific benefits of strip cropping. These benefits include an overall altering of modern production agriculture practices, with an easier way for growers to implement cover crops. In addition, the sunlight harvest strips have the possibility to dramatically reduce soil erosion, optimize a farm's inputs. This also gives the possibility to change what the world of what production agriculture machinery looks like. The main rationale behind adopting this practice, as our client hoped, is an overall increase in a field's productivity and sustainability. We recommend that more in-field research needs to be done to better quantify the nutrient, soil health, and environmental impacts of "Sunlight Harvest Strips."

3 PROJECT PLAN/OUTLINE

A. Methods/Approach

- Reference Material
    - We utilized information from textbooks and lecture materials from prior TSM classes including: TSM 324, TSM 330, and TSM 333.
- **Data collection**:
    - Most of our data was collected by Mr. Recker. We have analyzed harvest data and formatted it to evaluate economic effects.
- **Skills**:
    - It was imperative for our team to hold a firm understanding of this project. With that understanding, we were able to present the idea to many future customers/growers.
    - Information from TSM 324, TSM 330, and TSM 333 were utilized throughout the data analysis process.
- **Solutions**:
    - We utilized Mr. Recker's yield data throughout our analysis. We were able to evaluate the increased yield from improved sunlight utilization but discovered that it doesn't make up for the unplanted rows of crop.
    - Because there is a field wide yield loss, other factors needed to be evaluated including nutrients, soil health, and water quality improvements.
    - Mr. Recker will also have to continue his research with our recommendations as

a guide.

- **Organization:** Throughout the course we have communicated with our client and faculty advisor to keep us on track.
    - One of our biggest milestones was determining through an analysis if this will work or not based on 2016 economics.
    - From there, we then determined what route to take this project.
    - As final semester seniors, we devoted standardized time to this project and made sure we exceed all criteria.

B. Results/Deliverables

- We have returned a full analysis of yield data from Mr. Recker to provide a better view of the practice.
- We used the results to produce a production agriculture scale example of this farming practice with detailed accounts of different variables.
- We have evaluated overall farmer acceptance and their thoughts on this practice.

4 BROADER OPPORTUNITY STATEMENT

Sunlight Harvest Strips still has the opportunity to be the solution farmers have been looking for to increase their yields, while making their fields more sustainable for generations to come.

A. Our project was aimed at producing more crops on existing fields to address the current world issue of feeding a growing population. Addressing the triple bottom line of profitability, sustainability, and feeding the world is of the utmost importance.

B. Farmers who produce other crops besides corn and soybeans will be able to adopt “Sunlight Harvest Strips” more easily due to their equipment logistics. Farmers across the world may experience this similar issue. The main difference with this issue to other farmers across the world is some areas get too much sunlight such as Kansas, Texas, and Oklahoma. There, they are dealing with ways for their crops to receive less sun, and this proposed solution would be counter-beneficial to them.

C. Farmers are really the only ones who could use this solution to assist them with yields.

D. There are no trends that are affecting this practices broader opportunity. There is a dire need for an increase in yields worldwide to feed a growing population, while at the same time, we have less land available.

E. Other farmers are trying their own methods to increase yields. One potential solution is to use cover crops in the wintertime. This practice can cause some initial issues but once adopted shows a lot of promise. “Sunlight Harvest Strips” eliminate any competition between a cover crop and corn. Because there is not competition, farmers are more willing to try the new process. Some problems with cover crops is trying to discover the correct cover crop to be used in your field, time of broadcasting, and best management method to kill and deal with the crop.

F. Companies/Farmers are willing to spend money for a proposed solution to increase yields. However, they still want to see an ROI. A farmer does not stay in business if his current operation costs more than what they are getting out of it.

5 PROJECT SCOPE

A. The boundaries consisted of what our business wants from us specifically. The first main objective was to research economic results from current costs associated with corn production and the variance of input costs from this new proposed method. The second objective was to evaluate environmental impact that still needs to be researched to determine if these barren strips help with run off, water management, and compaction issues. The third objective was to collect opinions/concerns from multiple farmers throughout the ag industry. We have addressed their concerns throughout our project.
B. In our situation, the entire part of the business is focused on this current research project. This means that the entire business is included in this project.
C. There are no aspects outside of our team's boundaries.
D. These boundaries are what our business wanted from us through our constant research. He felt these boundaries best served our interests, along with his.

6 GRAPHICAL ABSTRACT

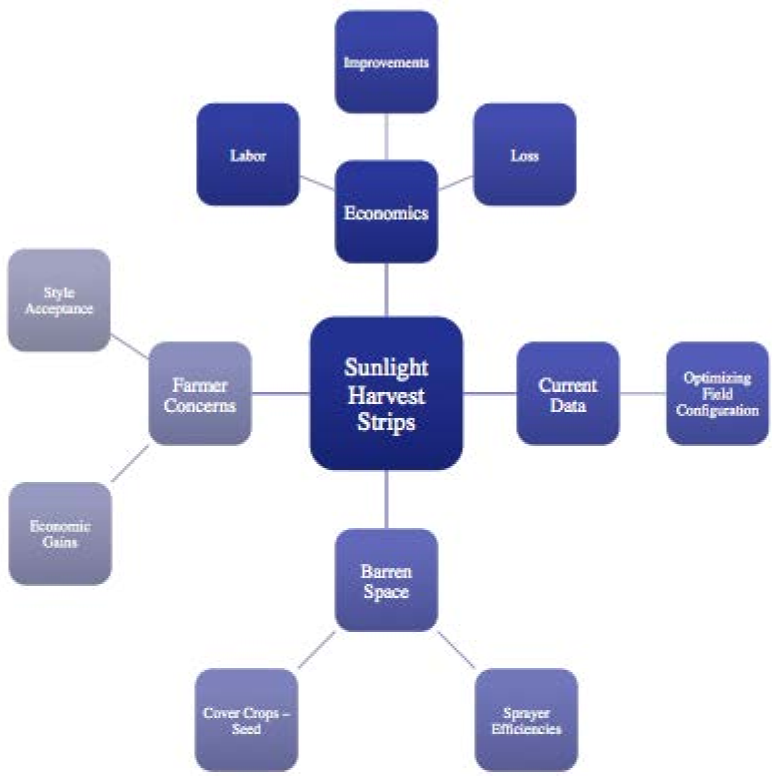


Figure 1. The graphical abstract outlines the portions of the project utilized. The group utilized current data to evaluate economics while addressing farmer concerns and determining how to utilize the non corn rows.

7 Appendixes

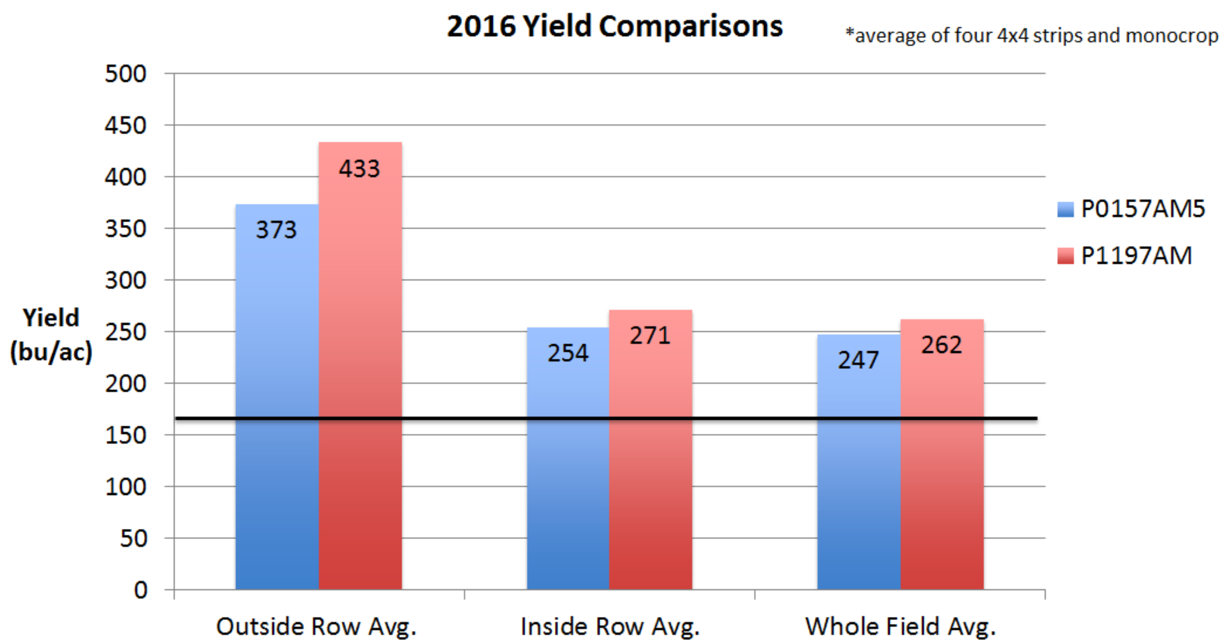
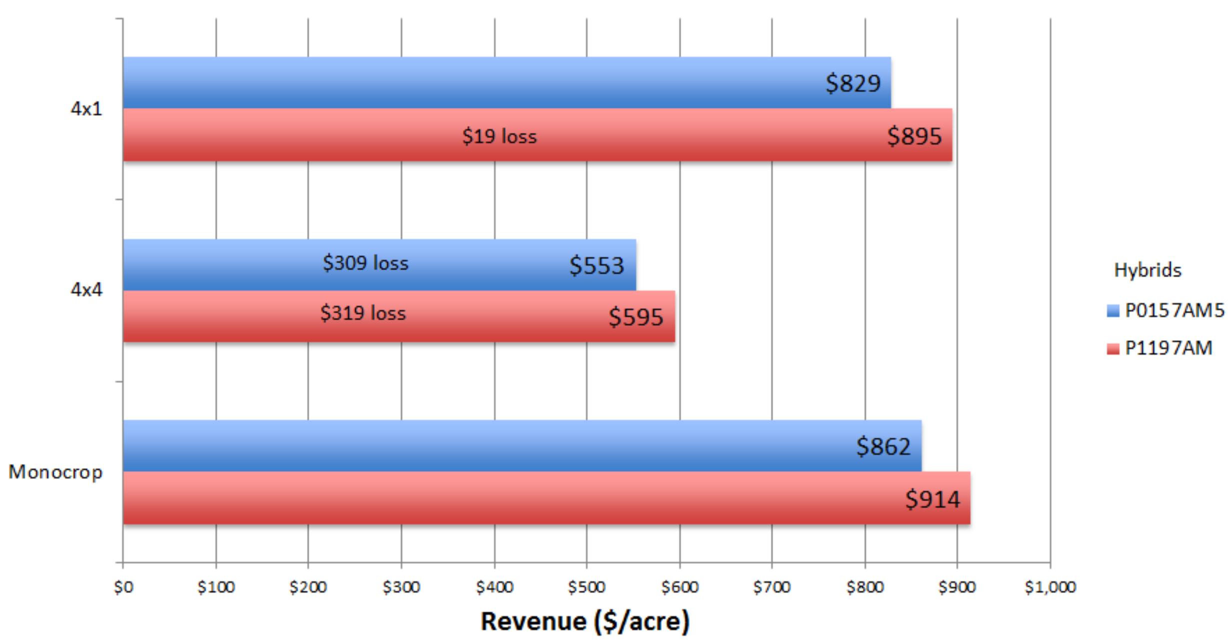


Figure 2. Yield comparisons regarding plot data for outside, inside, and total field average.



*Fall harvest price of $3.49/bu

Figure 3. Comparing revenue in $/acre regarding each different planting practice.

Field type	Strip Population/acre	Population/acre	Price to plant cover crops	Total planting costs
4X1	*43,750*	*35,000*	*-*	*$11,931.50*
4X4	*43,750*	*21,875*	*$488.50*	*$7,988.30*
Average field	*35,000*	*35,000*	*-*	*$11,931.50*

Figure 4. Calculations regarding cover crop planting. You will also find the data regarding each planting practice.

*Corn price is from a Pioneer rep. *80 acre field used for calculations *Based on ISU Custom Rates

Strip population/acre= Outer row population+Outer row population+inner row population+inner row population/number of rows in strip. ex. (52,500+52,500+35,000+35,000)/4

Population/acre= Population of strip*(number of rows planted/number of rows not planted). ex. 4X1: (43,750)*(⅘)=35,000 4X4: (43,750)*(½)=21,875

Price to plant cover crops=(Cover crop rate per acre)*(number of acres in cover crops). ex. cover crop rate per acre= 42 lbs rye + 1 lb alfalfa. Rye=$.2134/lb. Alfalfa= $3.25/lb. (42*.2134)+(1*3.25)=$12.21. Price to plant cover crops= $12.21*40 acres =$488.50.

Total planting costs= number of bags*cost of bags+price to plant cover crops. ex. 4X4:
Bags per acre= (population per acre/seeds per bag)=number of bags per acre. (21,875/80,000)= .273 Total planting costs= (Bags per acre*number of acres*cost per bag) + (price to plant cover crops)=total planting costs. (.27*80*$340.90)+($488.50)=$7,988.30

Crop	Alfalfa	Red Clover	Sweet Clover	Vetch
Nitrogen Credit	100 lb./ac	80 lb./ac	120 lb./ac	90 lb./ac
Nitrogen Value	$31	$24.80	$37.20	$27.90
New N Cost	$26.66	$32.86	$20.46	$29.76
Seed Cost	$3.29/lb.	$2.35/lb.	-	$2.45/lb.

Figure 5. Nitrogen economics in regards to cover crop implementation.

*Seed price from Stout Seed Sales *ISU nitrogen rate = 186 lb/ac *Avg. nitrogen cost = $0.31/lb

*Nitrogen costs = $57.66/ac

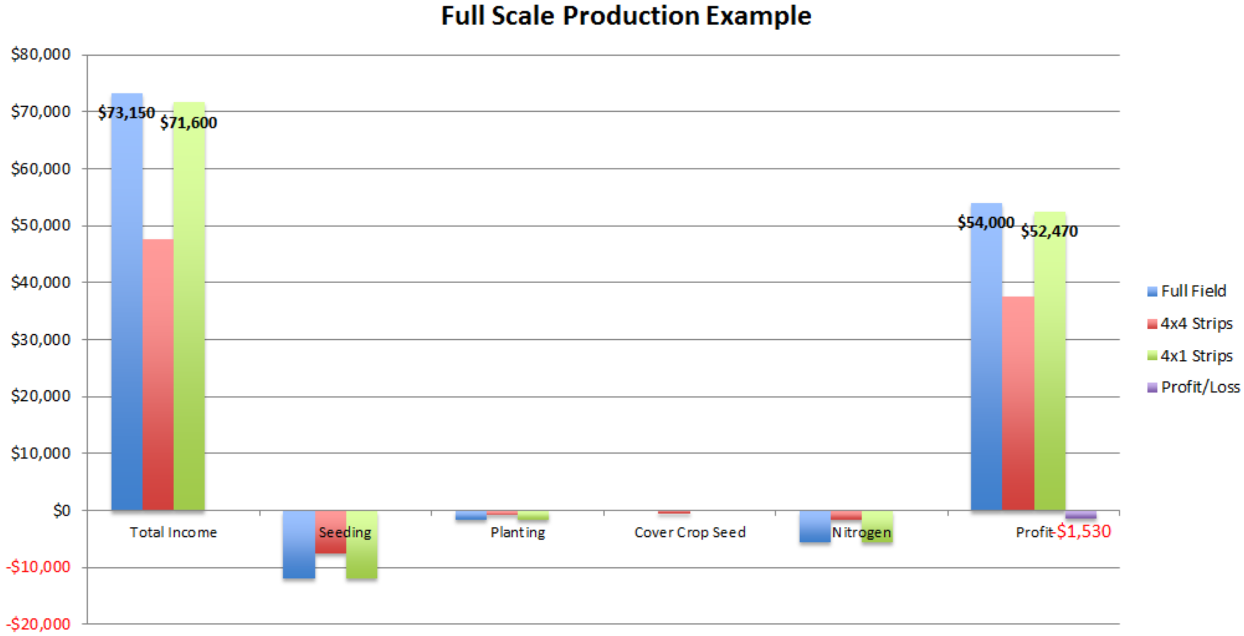


Figure 6. Production agriculture full scale production example. Comparing each planting practice.

P0157AM5	Ft of Corn	$/corn ac ($3.49)	$/ac ($3.49)	$ Revenue loss	Needed $/bu	Needed Yield
311	10	$ 1,085.39	$ 542.70	$ 319.34	$ 5.54	494
332	10	$ 1,158.68	$ 579.34	$ 282.69	$ 5.19	
316	10	$ 1,102.84	$ 551.42	$ 310.61	$ 5.46	
309	10	$ 1,078.41	$ 539.21	$ 322.83	$ 5.58	
		$ 1,106.33	$ 553.17	$ 308.87		
Check Yield						
247			$ 862.03			
P1197AM						
363	10	$ 1,266.87	$ 633.44	$ 280.95	$ 5.04	524
348	10	$ 1,214.52	$ 607.26	$ 307.12	$ 5.26	
356	10	$ 1,242.44	$ 621.22	$ 293.16	$ 5.14	
341	10	$ 1,190.09	$ 595.05	$ 319.34	$ 5.36	
Check Yield						
262			$ 914.38			

Economic Calculations:

Figure 7. Economic calculations were completed on Excel. The left column is the harvested yield at each replication of the 2016 harvest yield data. This analysis is for 4 rows of crop vs 4 rows of no crop. Corn $/acre is the revenue collected from the 4 rows of corn. This is based on the fall harvest price of $3.49.

$/ac is the collected revenue divided by 2 because revenue is only being collected from half of the acres. Revenue loss is based on the difference between the "Check Yield" and the calculated dollars per acre. The check yield is the "Monocrop" yield from Mr. Recker's harvest data. Needed $/bu is the price needed to compete with the "Monocrop" revenue. Needed yield is the yield needed at $3.49 to compete with the "Monocrop" revenue.

P0157AM5 Yield	$/corn ac ($3.49)	P0157AM5 Yield	$/ac ($3.49)	$ Revenue Loss	Needed $/bu	Needed Yield
297	$ 1,036.25	237.6	$ 829.00	$ 33.00	$ 3.63	309
(80% of acres)		(100% of acres)				
Check Yield						
247			$ 862.00			
P1197AM Yield	$/corn ac ($3.49)	P1197AM Yield	$/ac ($3.49)	$ Revenue Loss	Needed $/bu	Needed Yield
321	$ 1,120.29	256	$ 895.00	$ 19.00	$ 3.57	328
Check Yield						
262			$ 914.00			

Figure 8. The is table of calculations is very similar to the one above. We had a small amount of yield data on strips with one row gaps, which is why there is only one row of calculations for each hybrid. The first column of yield data is the average yield of the strip without including the blank row which would have a yield of 0 bu/ac. The second column of yield data includes the blank row yield data of 0 bu/ac which is why it is significantly lower. This yield is essentially represented as if the field was planted regularly as "monocrop".

Nitrogen Calculations:

Nitrogen Credit in Cover Crop Rows							
		.31/lb	186lb total				
Crop	N Credit	N Value	% of N use	New N $/ac	Total N $'s	$/lb	New N $/ac
Alfalfa	100	$ 31.00	54%	26.66	1066.4	3.25	$ (2.17)
Red Clover	80	$ 24.80	43%	32.86	1314.4	2.35	$ 4.03
Sweet Clover	120	$ 37.20	65%	20.46	818.4		$ (8.37)
Vetch	90	$ 27.90	48%	29.76	1190.4	2.45	$ 0.93
https://soilsextension.triforce.cals.wisc.edu/wp-content/uploads/sites/68/2014/02/Ruark.pdf							
https://www.extension.iastate.edu/agdm/crops/pdf/a1-20.pdf							
	$ 28.83	Total N $ per ac		N $ saved per 80ac			
	$57.66/ac	$ 2,306.40	Total N cost	$ 2,306.40	Total N cost Saved		
						$/bu	
					Rye	11.95	

Figure 9. This chart shows four different cover crops and their nitrogen credit based on the references noted. Using the ISU rates of $0.31/lb of nitrogen we calculated the value of the nitrogen credit. ISU also states that the average nitrogen application per year is 186 pounds per acre. The % of N use is the percent of nitrogen delivered by the cover crop. The New N $/ac is how much money is still needed to fulfil the nitrogen needs. Total N $'s is how much nitrogen will now cost on an 80ac field. $/lb is the price for a pound of seed based on Stout Seed Sales. ISU states that average nitrogen utilization costs

$57.66/acre. Over 80 acres this totals $2,306.40. According to our calculations, a grower could save substantially by using cover crops to deliver a nitrogen credit. Rye only costs $11.95/bu and doesn't need to be planted at a full bushel per acre.

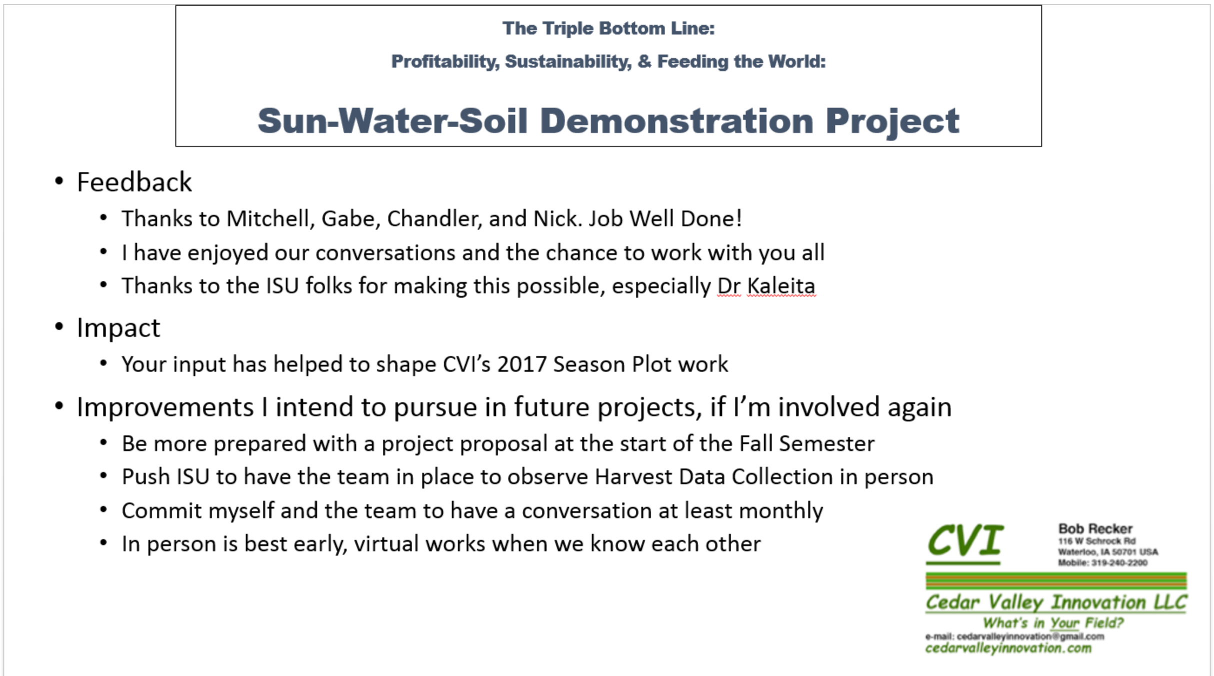


Figure 10. This is the feedback from Mr. Recker regarding our overall project and performance.