CPA# 5862391
2016 Commercial Food Waste Grant
Final Report

Grant Information	
Grantee:	Impact Bioenergy
CPA Number:	5862391
Project Title:	AD Digestate Field Study
Report prepared by (name):	Andrew Corbin
Date report prepared:	10/15/18
King County Solid Waste Division Grant Manager:	Karen May

Project Information

Provide an overall summary of the tasks and accomplishments of the project, based on project goals and objectives as outlined in the grant Scope of Work and Timeline. Capsulize information about the project that will allow county staff and potential interested businesses to learn key information about the project. Include the following:

- *a quantitative and qualitative assessment of the results and impacts of the project (including milestones achieved and results for other measurable deliverables)*
- *internal and external factors that contributed to or impeded the success of the project (what worked, what did not).*
- *an assessment of the potential for replicability and sustainability of the project by other commercial entities*
- *overall lessons learned.*
- *an assessment of the success of the Equity and Social Justice element of the project, if applicable*

Your grant manager will contact you if more information is needed.

The Anaerobic Digester (AD) Digestate Field Testing project has demonstrated a way to divert small business organics from their normal waste stream and convert those resources into renewable energy and liquid soil amendment for application on agricultural land. This project demonstrated how anaerobically digested food "waste" can be used beneficially within a community, avoiding trucking, export from the county, and the associated greenhouse gas emissions and loss of soil carbon. The approach for this project was to fully integrate zero waste, renewable energy, soil tilth and food production in our community.

We initially proposed the use of biogas as a source for heating a portion of the building, however, we did not fully implement the biogas due to the unpredicted rapid growth, significant remodel and modification to the buildings at Laser Cutting NW. We can say a few things about the potential however.

• We were simultaneously operating another HORSE digester at Microsoft Redmond campus for nearly a full year (2018). The biogas and food inputs at that digester showed an average of 0.84 ft3 of biogas per lb. of input (including liquid digestate added to emulsify the food waste). The rate was 2.28 ft3 of biogas per lb. of undiluted food waste.

- The statistics for the Microsoft Redmond were: 12,785 lbs. food waste diverted, 21,877 lbs. liquid added, and 29,179 ft3 biogas generated.
- We analyzed the methane content on several of our digesters. The Auburn digester serving the KC project showed a remarkable 81% methane. Other digesters in our system measured at 57%, and 67%. The average for all three was 68% methane. This is good news since we use an assumed 60% in our engineering calculations and the industry generally assumes 55% to 65%.
- Based on the total 8,241 lbs. of food waste diverted with this project we estimate the beneficial energy generated was 12,776,846 BTU or 3,741 kWh.

Commercial food waste was collected from Schilling Cider (Auburn), the Auburn Food Bank and the Quarter Chute Café (Auburn). All inputs were collected from these businesses that are located within a one-mile radius of the HORSE digester at Laser Cutting Northwest (Auburn), where the digester units are manufactured. Schilling cider waste consisted of spent yeast and wort, as well as finished cider that did not meet their quality standards. The inputs from Auburn Food bank consisted of food that had past the expiration date or otherwise spoiled and destined for the compost pile (regular pick-up for Cedar Grove). Quarter Chute Café waste included pre-consumer (processing trimmings etc.…) and post-consumer (compost) waste. Liquid soil amendment was originally applied at Seattle Tilth's (later Tilth Alliance's) Red Barn Ranch (Auburn) until the farm was closed, then at 21 Acres (Woodinville) in the fall of 2018.

The proposed target generators included Seattle Tilth Operations (Kent), Taylor Farms (Kent), Schilling Cider (Auburn), and the Auburn Food Bank (Auburn). However, by collecting just from Schilling, the Food Bank and with the addition of the Quarter Chute Café (Auburn), we were able to source all inputs within a one-mile radius from the digester. The changes from proposed were based on convenience of collection of inputs – and coincidentally – tight radius of travel. Seattle Tilth did not have a consistent supply of inputs and Taylor farms actually had too much

Proposed project tasks were accomplished as follows:

a. Quantities of food waste prevented and diverted, were logged at the time of collection. The pounds/tons of food waste prevented and/or diverted were measured by weight at the input end of the digester and reported quarterly.
b. Developed interpretive education and signage for collection site staff focused on source separated organics (SSO) to prevent contamination of SSO collected from materials such as plastics, glass, and metal.
c. Food waste was transported to AD site in Auburn for conversion to energy and soil amendment.
d. We maintained a log of collected food including the following parameters:
    i. Date collected
    ii. Waste generator
    iii. Volume
    iv. Mass
    v. Quality characteristics (e.g. embedded nutrients, energy water & carbon)
    vi. Any operational concerns (e.g. contamination or commingled yard waste containing woody matter)

Process via AD and log maintenance allowed the collection of data including:

- Amount of food in
- Amount of gas generated

- Amount of electricity generated
- Amount of soil amendment created
- pH
- Operating temperature

Field testing of digestate included the following process:

e. Development of field-testing protocols and methods including:
    i. Equipment needed
    ii. Application rates
    iii. Control groups
    iv. Scheduling
    v. Sampling
    vi. Analyses
f. Transport of liquid soil amendment to Red Barn Ranch and 21 Acres
g. Application to fields
h. Analyze/Measure:
    i. Digested food waste parameters including:
        a. Nutrients
        b. Water
        c. Organic matter
    ii. Observed plant growth response
    iii. Observed changes in soil quality
    iv. Farmers acceptance of liquid soil amendment
    v. Biomass growth comparisons (test cases vs. control cases)

Digestion inputs generated from Auburn Food Bank, Schilling Cider and Quarter Chute Café.

Measurable deliverables of food waste prevented and or diverted from the waste stream of Auburn Food Bank, Schilling Cider and the Quarter Chute Café:

Prevented

Total: 16,006lbs

Diverted

Total: 8,241lbs

“Prevented” refers to waste that came to the Auburn Impact digester rather than being trucked to a commercial compost facility or landfill and represents waste eventually processed through the Auburn facility, but not prior to the end of the grant period. “Diverted” refers to that waste which was processed via anaerobic digestion within the duration of the project. We initially proposed and expected to process all of the waste included in “prevented” and “diverted” within the scope of the project timeline, when we were looking to divert 12,250 pounds. The difference was primarily due to later than anticipated project start date, and some unforeseen mechanical problems as noted in the 2016 Q4 report.

Crops measured within the grant timeline did not benefit directly from digestate applications, however, long-term applications and measurements are required to realize potential benefits. Additions of anaerobic bacterial communities to an aerated soil die in an aerobic environment. These in turn are consumed by the naturally occurring microbial communities which, eventually lead to improved soil quality, subsequently benefitting cultivated crops. The scope of the grant timeline, coupled with the need to move the field experiment to a second field site prevented us from realizing measurable crop benefit. Long-term, consistent applications and measurements are needed to collect significant data and interpret the commercial value of AD food waste and how it can be utilized within a community. We did mitigate the direct cost and associated greenhouse gas emissions, minimizing the carbon footprint of the diverted and prevented waste that would otherwise have required trucking to a compost facility or landfill.

The potential for replicability and sustainability of this project will be conducted by other commercial and NGO entities. Digestate has been applied to a perennial alfalfa crop at Chinook Farm in Snohomish. Impact plans on repeating multiple applications on this crop through the life of the crop cycle (3-5 years). The Vashon Land Trust, now operating the former Matsuda farm is partnering with Impact to apply digestate on cover crops (spring/summer 2019) with subsequent applications via drip irrigation on target market crops in an experimental fashion.

Cumulative mass input (food waste) and gas output (methane and CO_2) at the HORSE in Auburn can be seen in Figures 1, 2 and 3. The Red Barn Ranch experimental field plot design can be found in Figure 4. Cover crop above ground biomass (Rye and Vetch) at Red Barn Ranch can be found in Figure 5, here we see a significantly higher yield in the control rye vs. the digestate treatment. These results are misleading however due to the extremely wet winter and ponding of water in one of the digestate replications. Differences in soil organic matter, CEC, P and Mn after one application of digestate at Red Barn Ranch can be found in Figure 6. Differences in soil organic matter, pH, P and Mn after two applications of digestate at Red Barn Ranch can be found in Figure 7. Figure 8 shows the medium red clover cover crop field experimental design at 21 Acres. There were no significant differences in above ground biomass for the clover cover crop and NDB (weeds) at 21 Acres (Table 1). Soil analyses for clover cover crop at 21 Acres show a significant increase in NO_{3-} nitrogen in the digestate treatment as compared to the control (Table 2). The oats and peas cover crop field experimental design at 21 Acres can be found in Figure 9. Soil analyses for oats and peas cover crop at 21 Acres show a significant increase in NO_{3-} nitrogen and calcium in the digestate treatment as compared to the control (Table 3). These increases in NO_{3-} nitrogen and calcium show a potential for the subsequent crop to be improved over no addition of digestate.

Replicability and sustainability

This project is highly replicable and sustainable. A digester of this size can support 350 – 400 people (one meal a day basis), or 150 – 200 people (three meals a day basis). It can also generate about 5,400 gallons of probiotic natural liquid plant food per year – reducing the need for petrochemical inputs to the soil and food supply.

Companies/individuals/governments can pursue something like this because zero waste, clean energy, and growing healthy food are universal aspirations.

This project is inspiring and enabling people to find a better way to move water, carbon, microbes, and organic matter back to the soil.

Rarely does an opportunity come along that can positively touch on energy, water, air, soil, food, jobs, and education simultaneously.

Lessons learned

The primary lessons learned are:

1. This is the smallest digester we would recommend be implemented, rated at 25 tons per year diversion. We can design and build a single digester module ranging from a low of 25 tons per year to a maximum of 1,500 tons per year (i.e. Vashon Bioenergy Farm).
2. We found the markets for liquid plant food made from digested food waste require more analytical field trials to fully express and communicate the benefits. Over time we expect more data to become available. This represents an opportunity for King County to support growth results and public education.
3. We believe the recycling value of a distributed digester network to be equal or greater than the cost of curbside collection, transport, and tipping fees at a centralized processing or disposal site. King County may be able to further illuminate this and help confirm our belief.

Equity and Social Justice

1. The primary benefit of this project was to make the local Auburn Food Bank more resilient and sustainable. We helped the food bank avoid collection, hauling, and processing/disposal fees. This helps the financial viability of the food bank.
2. We believe the localized nature of this concept helps any group of people grow healthy food locally with less chemical exposure and to become more self-reliant. This speaks directly to addressing problem of urban food deserts. We have one project in NYC that is specifically designing a HORSE and year-round food hothouse at low income housing.
3. We are working other food banks to help them reduce their cash spending on waste hauling.
4. This project offers an alternative to large centralized processing, bringing resource management closer to the waste generator. Generally, this is considered a more socially just way of managing waste.

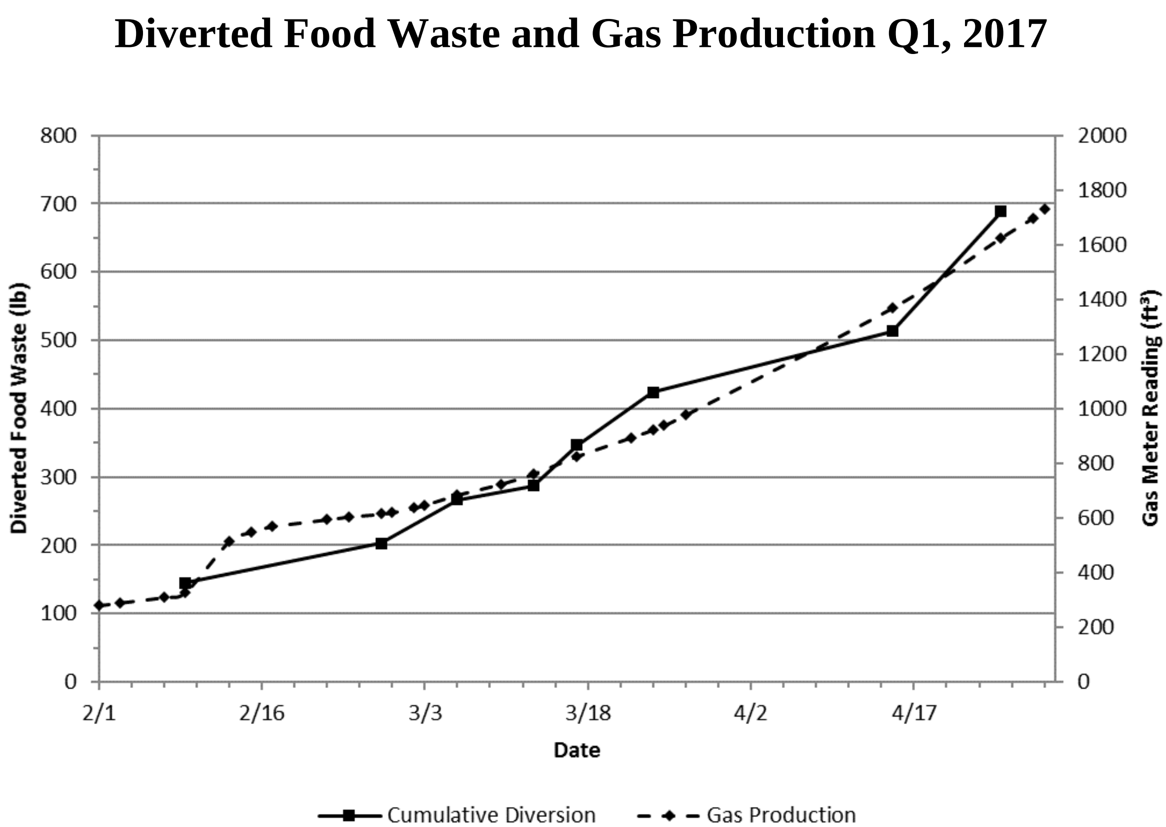

Fig. 1. 2017 Cumulative mass input (solid line) and gas output (broken line) for Q1 at the HORSE in Auburn.

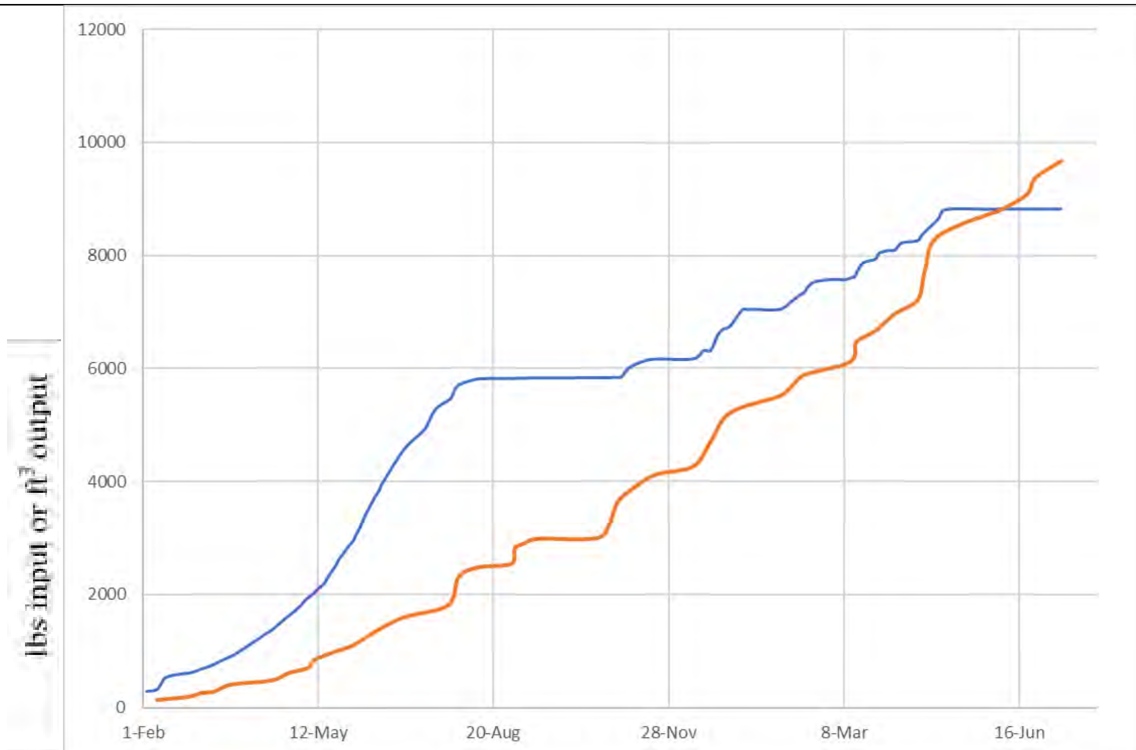

Fig. 2. 2017-18 Cumulative mass input (orange line) and gas output (blue line) at the HORSE in Auburn.

Diverted food waste from the Auburn Food Bank and Schilling Cider (above) and the Quarter Chute Café (below).

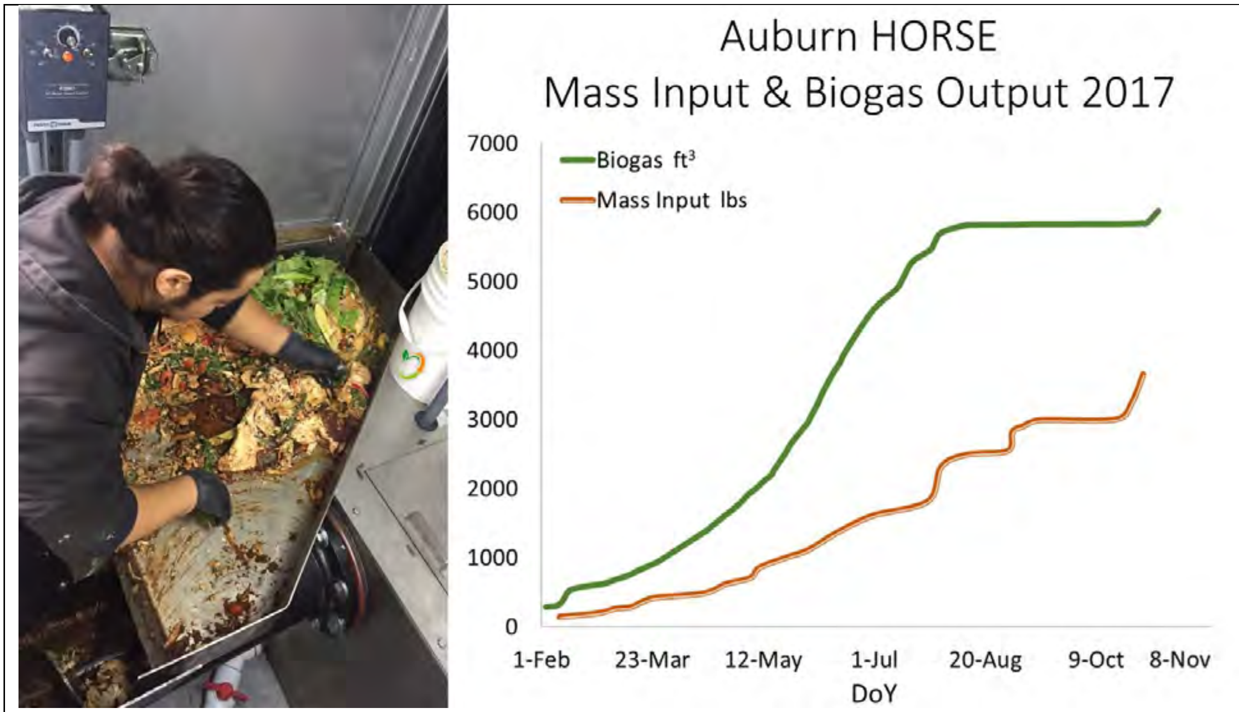

Fig. 3. 2017 Cumulative mass input (green line) and gas output (orange line) at the HORSE in Auburn.

Liquid soil amendment barrels for filtering, and spray tank for field application

Field application of soil amendment on fall cover crops at Red Barn Ranch in Auburn

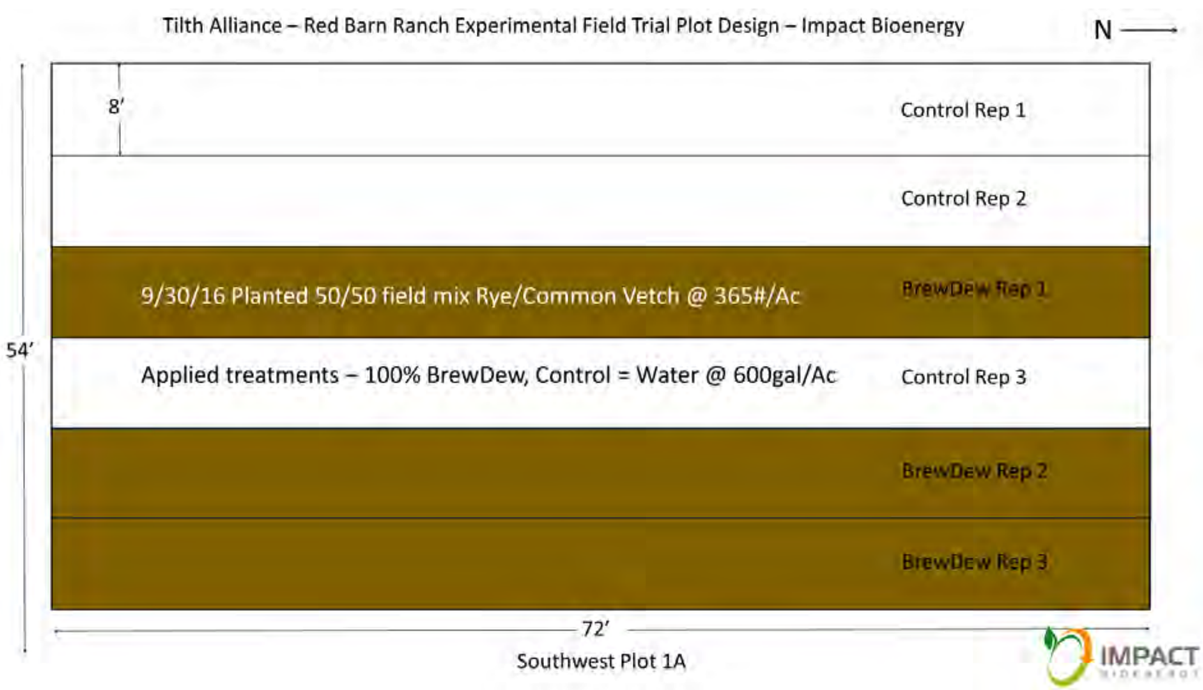

Fig. 4. Initial field experimental design at Tilth Alliance farm at Red Barn Ranch

Sampling above ground biomass on rye/vetch cover crops at Red Barn Ranch in Auburn

Weighing dried rye/vetch cover crop biomass at Red Barn Ranch in Auburn

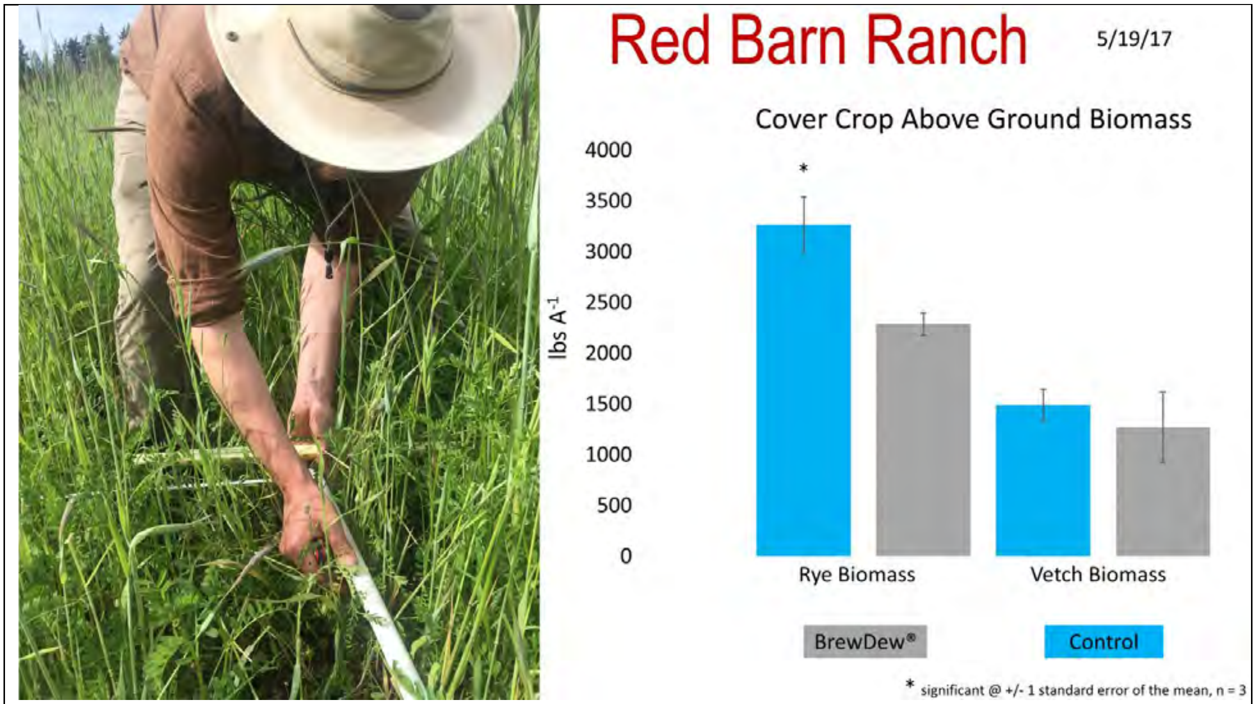

Fig. 5. Cover crop above ground biomass at Tilth Alliance farm at Red Barn Ranch

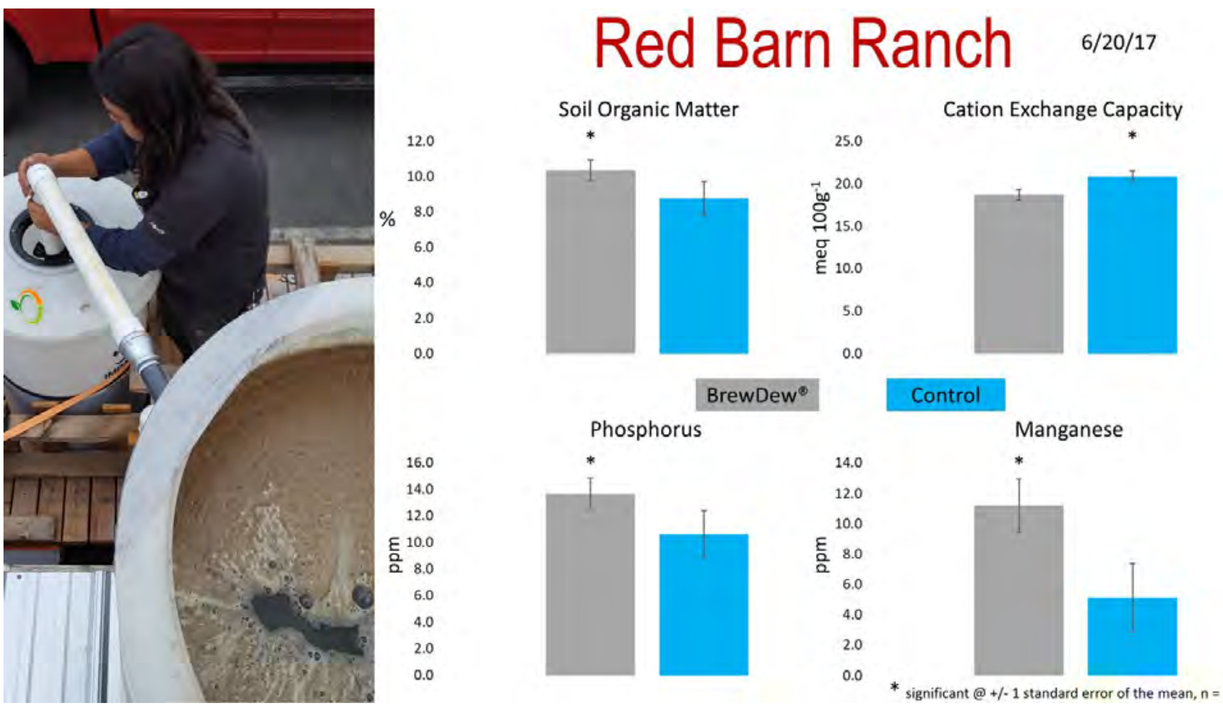

Fig. 6. Soil organic matter, CEC, P and Mn after one application of digestate at Tilth Alliance farm at Red Barn Ranch

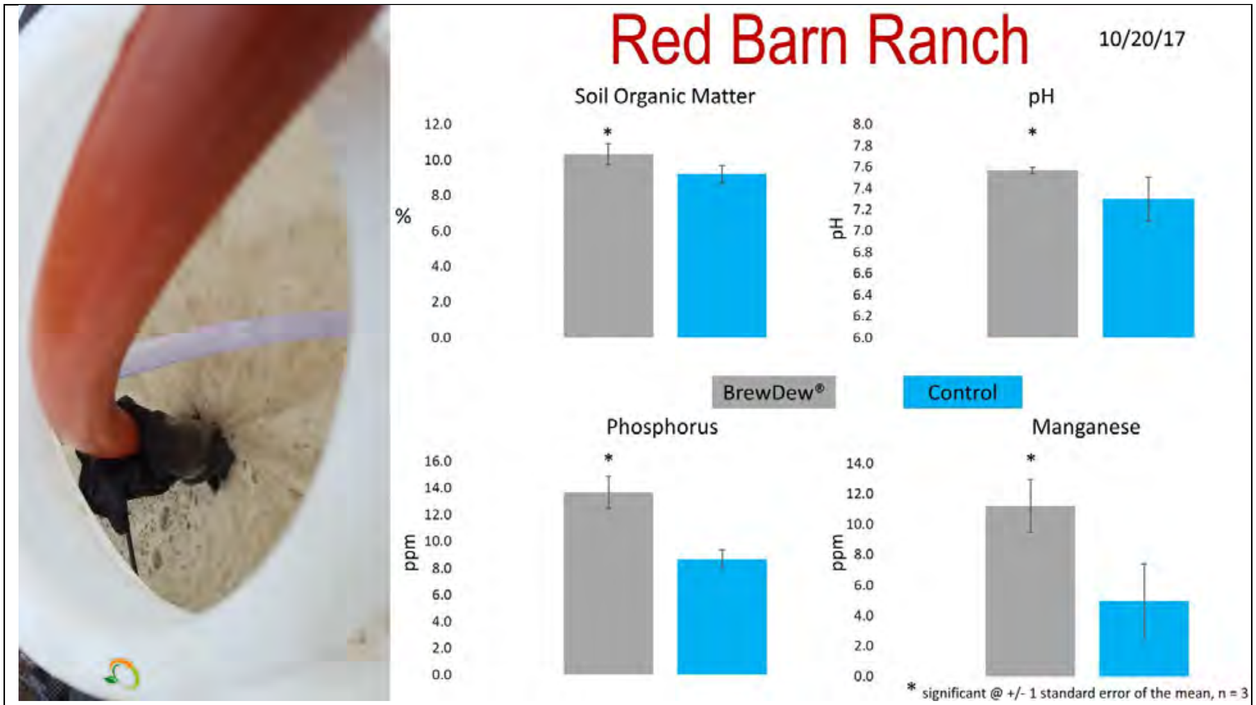

Fig. 7. Soil organic matter, pH, P and Mn after two applications of digestate at Tilth Alliance farm at Red Barn Ranch

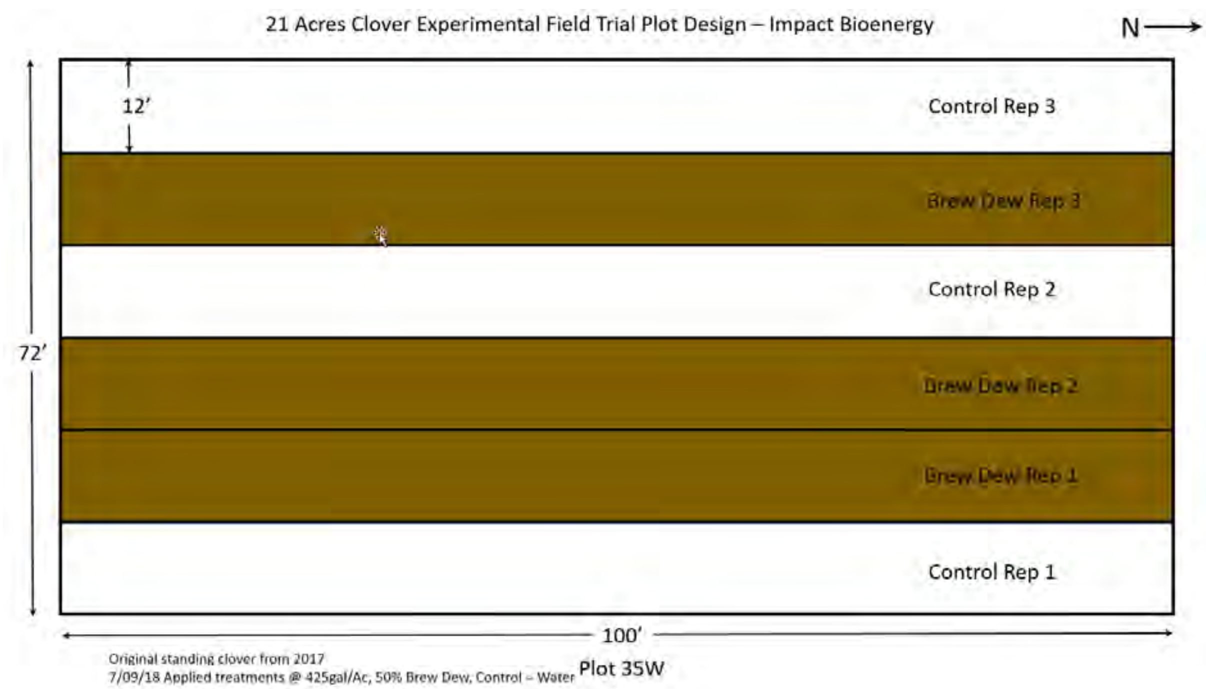

Fig. 8. Medium red clover cover crop field experimental design at 21 Acres

Sampling above ground biomass on clover cover crop at 21 Acres in Woodinville

Sampling above ground biomass on clover cover crop at 21 Acres in Woodinville

Treatment	Mean	SEM	P-value
Clover:		0.1240371	0.4144
control	0.5383		
brewdew	0.6979		
NDB:		0.01736097	0.918
control	0.0256		
brewdew	0.0281		

Table 1. Above ground biomass for clover cover crop and NDB (weeds) at 21 Acres

Clover Soil, bold indicates significant differences @ p = 0.05					
	TC means	TC SEM	TB means	TB SEM	p-value
01:01PH	5.9667	0.1202	5.9000	0.0000	0.6349
Buffer	6.0667	0.1333	6.0667	0.0882	1.0000
Bray	11.0000	1.5275	9.3333	0.6667	0.3974
K	54.6667	2.9059	47.3333	4.9777	0.2873
NO31	**9.1333**	**1.0333**	**13.9000**	**0.8544**	**0.0251**
OM	11.8000	2.1197	11.3667	2.1419	0.8926
CA	14.5333	1.8800	13.5333	1.0729	0.6739
MG	2.8333	0.2963	2.7000	0.2646	0.7542
CEC	24.7333	2.4456	23.4333	2.5406	0.7311
SOLSALT	0.3380	0.0520	0.3553	0.0607	0.8391
S	9.7833	0.7051	9.4667	0.6317	0.7550
X16	0.1800	0.0058	0.1800	0.0208	1.0000
ZN	1.8000	0.4583	1.3667	0.1764	0.4520
FE	241.6667	24.3744	244.6667	9.5277	0.9170
MN	2.7667	0.4055	2.4000	0.4583	0.5818
CU	1.5667	0.0882	1.6000	0.2000	0.8893
B	0.6300	0.0651	0.5833	0.0874	0.6923
NH4-N	4.9667	0.7753	3.5333	1.0203	0.3301
CaCl2 pH	**5.5333**	**0.0000**	**5.3667**	**0.0333**	**0.0241**

Table 2. Soil analyses for clover cover crop at 21 Acres, TC = Control, TB = BrewDew

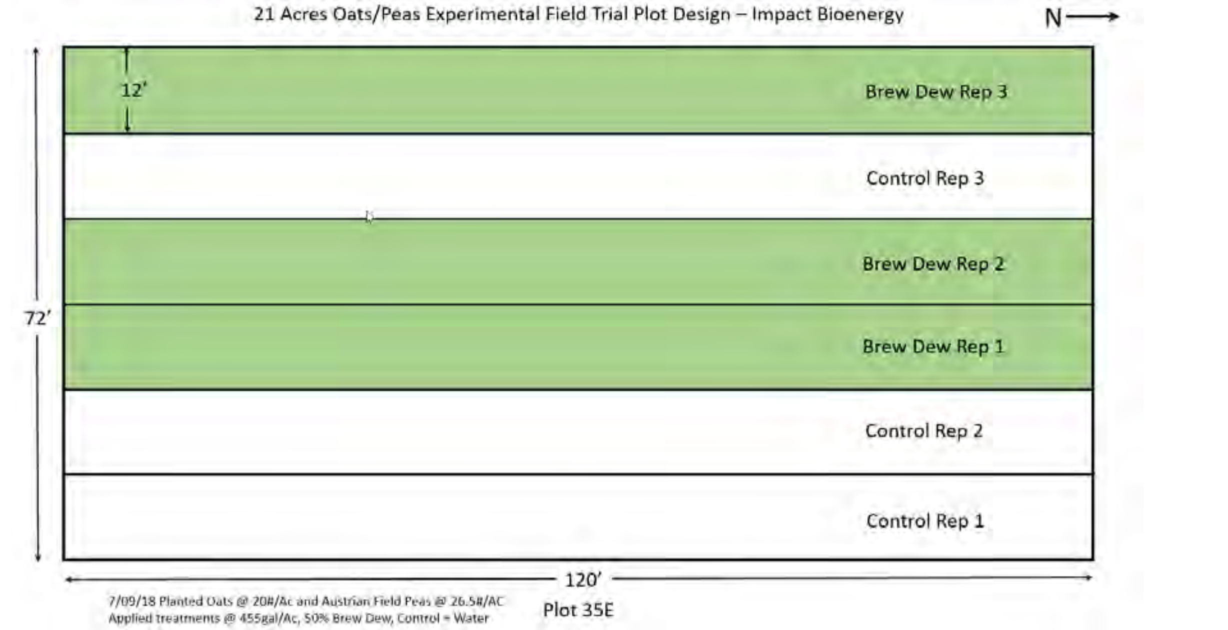

Fig. 9. Oats and peas cover crop field experimental design at 21 Acres

Oats and peas Soil, bold indicates significant data @ p = 0.05					
	TC means	TC SEM	TB means	TB SEM	P-value
01:01PH	5.8000	0.0000	5.7667	0.0667	0.6667
Buffer	6.3667	0.0882	6.1667	0.0333	0.1394
Bray	6.0000	0.0000	7.6667	0.6667	0.1296
K	32.6667	4.0961	35.3333	4.9103	0.6987
NO31	**26.9333**	**1.6974**	**36.2333**	**2.6460**	**0.0509**
OM	10.5000	0.1732	11.4667	0.6936	0.2962
CA	**15.1667**	**0.3180**	**17.0667**	**0.5239**	**0.0470**
MG	3.2333	0.2404	3.5667	0.1856	0.3376
CEC	30.4000	1.3051	29.9000	0.9849	0.7761
SOLSALT	0.5720	0.0260	0.7713	0.1511	0.3170
S	14.7767	0.7424	16.2667	0.5832	0.1936
X16	0.1567	0.0120	0.1500	0.0153	0.7498
ZN	1.9333	0.2728	2.3667	0.2667	0.3195
FE	197.0000	24.6644	232.3333	11.9210	0.2908
MN	1.7000	0.3000	2.0667	0.1453	0.3544
CU	0.8667	0.0333	1.1333	0.1202	0.1488
B	0.3667	0.0393	0.4200	0.0300	0.3453
NH4-N	4.7333	0.0667	2.9667	0.5239	0.0755
CaCl2 pH	5.4333	0.1333	5.4000	0.1000	0.8520

Table 3. Soil analyses for oats/peas cover crop at 21 Acres, TC = Control, TB = BrewDew

Provide any other information that the grant manager should know about this project.
Provide feedback on your experience with this Commercial Food Waste grant program. Do you have suggestions for how to improve the program?
We at Impact Bioenergy believe the Commercial Food Waste grant program through King County SWD is a perfect fit. Perhaps some more cross-functional collaboration and support from SWD for longer term studies would be a win-win for the SWD and the organic recycling industry. Considering the results of our field experiments thus far, it seems longer term experiments with multiple applications could enhance soil quality and eventual positive significant results on target crop biomass. Partnering with the two NGO, non-profit farms for the field studies proved to be a bit problematic - the first one (Red Barn Ranch) closed and the second one (21Acres) lost their farm manager during the grant cycle. Partnering with an interested, well-established commercial farm may go a long way to prove more positive, replicable results.