Black Solider Fly Larvae Composting at Bell's Brewery

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Already a pioneer in sustainable brewery management practices, Bell's Brewery, Inc. of Kalamazoo, MI is currently seeking to divert 100% of the solid waste stream generated at their facilities. More specifically they are seeking to eliminate the organic solid waste that is a byproduct of the filtered wash water called 'screening solids'. Historically, Bell's has done a remarkable job with solid waste management. In 2013, they had a 90% diversion rate with a net cost of only $96! In 2015 an anaerobic bioreactor was commissioned and unfortunately created a new solid waste problem. With an estimated conservative 20% increase in production, the gross cost to landfill will increase linearly. In this project we explored landfill diversion with black solider fly larvae (BSFL) composting through a pilot study at WMU's Gibbs Farm.

Fundamental questions:

To begin our pilot study we identified a few fundamental questions: Can BSFL eat the screening solids? If so, what are the volume reduction rates? Are there any specific inputs required such as energy or carbon? Say the pilot study goes well; what does this look like for Bell's?

To address these inquires we conducted three main experiments. Each experiment was carried out in three Protapods™ and a do-it-yourself (DIY) compost bin with approximately 10,000 larvae per bin.

Experiment #1: WASTE REDUCTION RATIO

DIY 5 had a total input of 28.6 kg (63 lbs) screenings between February 13 and April 10. The total end harvest was 1.4 kg (3.1 lbs) of castings. The waste reduction ratio resulted in a 20.3:1, waste input to castings output ratio. The moisture content of the castings did not play a significant role in the waste reduction ratio. However we noticed more pupae inside the wet output.

We can conclude from the first experiment that the 20:1 input to output ratio was verified. For every 2 cubic yards, or 1,700 lbs of screenings input, Bell's will collect an approximate output of 2.7 cubic feet, or 84 lbs of castings. If Bell's were to continue to landfill the castings after the screenings volume reduction, it is estimated that they will have an annualized savings of $24,624 in 2015. With an estimated annual 20% increase in production, you can observe the linear relationship in Figure 9 of the full report.

Experiment #2: TEMPERATURE NEEDS OF LARVAE

We observed that the compost pile temp is 15° F +- 5° F warmer than the surrounding air temperature inside the bin. BSFL can survive in the range of 4° to 43° C (39° to 109° F). However, if the compost pile temperature exceeds 35° C (95° F), premature crawl off will be experienced with a corresponding reduction in feeding efficiency. If the compost pile temperature falls below 18° C (64° F) larval feed rates will decline. To ensure the temperature does not exceed this range, we recommend Bell's regulates the compost pile with a sensor positioned inside the compost pile. Air temperature is a secondary consideration to regulate because if air temperature falls too low the grubs will pupae inside the bin.

An indoor compost system during the cooler, winter months will require additional heating to maintain the system from falling below 18° C (64° F). The additional heating will be at a minimum due to the heat produced by the larvae. Additionally, an indoor compost system during the warmer, summer months will require ventilation and possibly cooling so that the compost pile does not exceed 35° C (95° F).

Experiment #3: CARBON: NITROGEN RATIO

As a result of the carbon to nitrogen ratio inside the compost bins, we found that the larvae prefer nitrogen-rich organic material over carbon-rich organic material. By observing the level of decomposition and location within the bin, the leaves went untouched for 58 days of the experiment beginning March 3 and ending April 30. A carbon addition of 2 lbs to 63 lbs screenings was observed to decrease the ammonia smells to an unnoticeable level that was much healthier for the operator.

We can conclude that carbon will eliminate the smell of ammonia; though, it is not necessary for the functioning of the system. Excess ammonia gases pose a threat to the operator's health if inhaled. Since the waste Bell's is dealing with is nitrogen rich, we recommend adding a minimal amount of carbon to the system to reduce odors. Carbon sources can come in many forms but sourcing a locally available bulking material is recommended to reduce transportation costs, expense in handling a bulky material, and carbon footprint. We suggest further research to quantify the correct carbon to nitrogen ratio needed within a BSFL compost bin as no published data could be found.

Operational Scope:

With an estimated 2 cubic yards of screenings solids input each day, a system at Bell's will produce approximately 62 gallons of leachate and 2.7 cubic feet of castings per day. The total weight of pupae output is to be determined; however will be dependent on the larval input. Each of these byproducts possess a significant market value. The leachate and castings can be utilized as a fertilizer, while pupae can be used as a high protein-high fat animal feed. Further detail regarding the significance of system byproducts can be found in the full report.

BSFL System Input	BSFL System Output
• Larvae: 480 lbs/ month • Screenings solids: 2 cu yd/ day • Carbon: 3 cu ft/ day	• Leachate: 62 gal/ day • Castings: 2.7 cu ft/ day • Pupae: larval input/month

Altogether, a system for Bell's will require an insulated building to replicate and maintain optimal environmental conditions. Daily feed input must stay relatively consistent and we recommend an additional input of carbon. The system we created at the Gibbs farm can be scaled up, however we must find a solution to breeding BSF's for this project to be successful. It becomes impractical to perpetually purchase a new starter colony of larvae each time they reach their full life cycle. As stated before, landfill costs are linear to growth in production. If BSFL composting were to be implemented at Bell's, the reoccurring costs of hauling and landfilling could be eliminated or significantly reduced.

Limitations of analysis and proposed future work:

- Exact C:N ratio
- Redesign the in-house compost bin due to pupation inside bin
- Nutrient analysis
- Energy efficient practices with zero energy inputs
- Weight increase of larvae
- Feed conversion rate at different temperatures

For more information please see the full report at:
http://wmich.edu/sustainability/reports-publications/green-jobs-student-reports