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AG 230 Section 1 Project (2156 words)

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Black Soldier Fly Hydroponics System

Abstract/Summary

The objective of this project was to build a black soldier fly (BSF) hydroponics system on the University campus in a conspicuous area. My main purpose was to generate interest and disseminate information about using the BSF in this way for family sized sustainable gardening. Required activities would include generating interest and support within the agriculture department, securing funding if possible (or fund myself), design and build the unique structures, initiate a BSF colony in the roost, and finally to get some plants started. Some of the challenges included dedicating time from my own very busy 18 credit class schedule to build the structures, and while UH was amenable to funding the project, actually getting some of the components ordered which were not able to be sourced locally delayed progress. In the end, spring break allowed me some time to make significant progress, and Professor Arancon secured the needed components. The project did come together well, with the only goal not achieved is the seeding or planting as the BSF colony is not established at a level enough to generate the needed hydroponic nutrients.

Introduction

The BSF larvae live as a maggot for 6-9 months, then pupate into a fly which lives only 3-5 days, during which it does not eat (no mouth parts), it only mates, lays eggs by a suitable hatching place and dies.

During the feeding months, it and it's cohorts are able to eat a large amount of food waste in a short amount of time, often hours or overnight. It seems like this process is similar to vermiculture processing. The end result is waste reduction in volume by often over 50%, and inclusion of beneficial bacteria. This resulting BSF Compost is then added to a hydroponics reservoir and used in a typical hydroponics system. Included in the system is mosquito guppies living in the nutrient solution in the reservoir, and many earthworms living in the growing trays. Neither of these last two is required, but both likely contribute to an overall healthy system.

I have been very successful with my growing system creation, and I assumed that it was “sustainable”, although I had not looked up the agricultural definition. Once in my AG 230 class, it does indeed seem that the system meets all seven principles of sustainable agriculture. In my home system, I have been growing tomatoes, cucumbers, carrots, beets, lettuce, arugula, green beans, peas, strawberries, onions, zucchini, bell peppers, celery, various herbs, and others while *only* adding my own food waste to the system.

Materials and Methods

I've been using this method of BSF hydroponics since 2011 to grow my own food at my home. It was born out of frustration in attempting to soil garden, and being unhappy with every method I tried. After disappointment with an aquaponics attempt, I struck on the idea to try the BSF compost as a compost tea... it was extremely successful.

For 2 years, I didn't think much about the system other than growing my own food in two 8 foot long trays just set on top of a reservoir. Not pretty, but got the job done.

Then I came across an “Innovation in Agriculture” contest, which inspired me to design and built my current home system using three, 3'x3' trays, in a design that looks similar to a fruit stand. The contest judges determined that it “stinks, and has too many moving parts”. Hummm. Exactly the opposite of what the system is. But, it caused me to create a “pretty” designed system which would engender a closer look by University of Hawaii (UH) Professor Arancon, so I'm thankful for the contest entry for that reason.

During the development of my home system, I determined that two separate BSF bins would be used. The first is used to add new food to it for approximately two weeks (or 3-4” of depth of compost & food waste), then you stop using the first, and use the second bin the same. After two weeks, I would then dump the contents of the first bin that has been resting for two weeks into the reservoir and stir it up well, then begin using that just dumped bin for the food again, and continue the bin rotation schedule. This worked pretty well with a screen on the pump, but it did require handling the compost, and eventually dredging out the reservoir. I knew that for this to be a “easy” system, that the compost would need to be rarely handled in order to be acceptable and used by the average person.

Eventually I created screen bottomed BSF bins, and mounted those directly above the reservoir. This would allow a user to simply wash the BSF compost in situ, and if they are careful not to add non-food items (like egg shells or papaya seeds), there would likely be very little if anything remaining to be removed at a later time. The average-user configuration was born.

All of these experiences and developments before attending my AG 230 class allowed me to generate additional ideas for improvements to the BSF bins and reservoir system. I constructed the UH system using three 4'x4' trays, which nearly doubles the growing space, and accordingly, increased the size of the reservoir (150 gallon). When I started this project, I had a general idea of what I wanted the BSF bins & reservoir to accomplish, although no defined or drawn plans.

I constructed the UH main BSF tray stand structure using a similar design as my home system, just larger. It's simple, and makes the most of the redwood construction materials. I chose redwood from experience with treated lumber still being susceptible to both rot and termites after only a few years here in Hawaii. The design allowed for very minimal waste, less than an equivalent of one 2”x4” by eight foot was left over in small pieces. I was asked to stain the wood, which does add to the systems visual appeal, so I'm glad I did. I offered to my fellow students on several occasions if any wanted to assist me outside of class time on the construction, but none were interested or perhaps too busy. This suited me fine as actually since I was working off loose plans, it would have been difficult to assign a task. Professor Arancon did assist me on several occasions which I appreciated.

With the stand's wood construction completed, and agricultural grade roofing stapled on, it came time to build the BSF bins & reservoir, an integrated BSF roost. I specifically need to keep the BSF maggots and flies captive, while allowing their easy access to the the food bins, space to fly and mate, and yet access to the reservoir. I utilized a couple of extra large dog food bins I had used at home previously, and removed the bottoms. When I installed into the roost, I used stainless steel window screening. The sides of the roost are a green house insect screen which has very tiny holes, probably ¼ the hole size of window screen. The top and doors are covered in a longer-life agricultural roofing material (10 years?) which is clear with white fibers running in a crosshatch pattern. The screen and roofing are all stapled with stainless steel staples, while the bin bottoms are secured with strips of wood and screws. There is a 3/4” pvc pipe coming up in the middle between the two bins and has a flexible hose long enough to reach into the bottom of the bins, which is used to wash the compost. The design includes open air access to the reservoir water specifically so that fish can be added to the reservoir. There is an aerator for the reservoir, both for the mosquito guppies and to provide dissolved oxygen for the beneficial bacteria. The aerator runs automatically during the daytime via the solar panel and timer, 40 minutes on, and 20 minutes off while the water pump is on. There are no batteries, and so the system shuts down overnight, which is common with traditional hydroponics. The valve in the picture when closed (shown open in pic next page) causes the pressure to build up, and travel the four feet up into the washing hose when the pump is in it's running cycle.

The solar system utilizes two 12v, 50 watt panels, mounted at a 90 degree angle to each other, and oriented south. The panels are slightly over sized for the power required so that during overcast days, the system can still operate normally. The eastern rising sun to strikes the first panel at sufficient angle to immediately start up the system. Likewise, at sundown, the other panel is able to remain operating as long as possible. If the panel was flat, you would likely loose 4-5 hours per day of operating time due to a significant sun angle to the surface. Since the solar panels create up to 22 VDC in full sun, and our pump, aerator, and timer use only 12v, there is a 24v to 12v regulator to prevent over voltage and burnout of those devices.

In order from left to right:

The **pump** is a 360 gallon boat bilge submersible pump (120 gallons in 20 min on time)

The **aerator** is a standard 12v aerator used in fishing boats, etc.

The **regulator** is 24v to 12v, 5amp

The **timer** is 12v, 16 amp, and has 17 programmable settings; the 17 cycles allows for 6am on, 6:20 off, 7am on, 7:20 off , continuing until 8pm on, 8:20 pm off. The timer has only a normally open relay (NO), and since we have two devices to turn on, one during the timer off cycle, it requires the addition of a double pole 5 amp relay (see electrical drawing).

The plumbing under the trays and connecting to the reservoir are a combination of black vinyl hose (clear would allow sunlight, algae would form, and eventually plug up the hoses) from the hydroponics store, and PVC pipe (any hardware store). The inlet ebb/flow tray fittings come with a 1/2” hose barb, and the outlet fitting a 3/4” hose barb. This is expressly so that the pressurized incoming nutrient solution can never over fill the tray which is drained by gravity. The pump has a 3/4” outlet, and so I used 3/4” black vinyl to connect to 3/4” PVC pipe, which then returns to 3/4” vinyl hose, and finally, a reducer from 3/4” to 1/2” at the ebb/flow fitting. The reduction is done at the end to ensure that the full volume of nutrient solution is available to all fittings mostly equally. The overflow must remain in 3/4” hose, and when the three overflow hoses join the overflow manifold, the pipe size jumps to 1”, again to ensure that the overflow from all three trays could never be more than the piping could handle. If this did ever occur, then the trays would overflow their sides and you would loose your nutrient solution on the ground :(. The ebb/flow inlet fitting is mounted on the floor of the tray, when the pump turns off, the solution flows back into the reservoir by going back through the pump. The overflow fitting and piping is only used once the tray is completely full.

Conclusions and recommendations

I'm disappointed that I was unable to get a BSF colony established in the UH system before the end of the semester, and so was unable to plant. However, the system turned out beautifully, and is will be soon able to sustain a garden as long as somebody adds food waste at least weekly. I saw today the first black soldier fly hatched, and so now the watch begins for a clutch of eggs, and then a few days later that they have hatched.

I really enjoyed the opportunity to discuss the system with handful of people who would drop by and see what the system was about while I was working on it. A few people have already begun looking into setting up a system of their own at home, and I just heard a local nursery is interested in building a system, and developing relationships with individuals interested in creating turn key systems for sale. This is awesome since my ultimate goal is for as many people to learn about this system as possible, and to grow their own food.

My hope is that this document, in addition to the website I've started working on at www.BSFHydro.com will become a resource for future students as they use the system at UH. There is already significant additional information on using the system at the website address, and would make this paper too long (and outdated). As well, I'm happy to field any questions at OwensW@Hawaii.edu.

Electrical Configuration