MT. SAC
Mt. San Antonio College

PRESIDENT'S STUDENT SUSTAINABILITY AWARDS SUBMISSION FORM

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NOTE*: Individuals and Groups may submit to multiple categories but each submission requires a separate email including a submission form, 250-word essay, and the submission work as an attachment or links.*

Category of Submission (choose one):

Artistic Expression; Innovative Idea; **Research**; Student Leadership

What semester in 2016 did you complete this work (choose one):

Winter; Spring; Summer; **Fall**

Did you complete this for a class? If yes, please list the course name and instructor:

BIOL 4H; Cindy Shannon

Submission Contact Information:

Are you submitting as an **Individual** or as a **Group/Club**? Individual

- *If you are submitting as an* **Individual***, fill out the following information:*

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- *If you are submitting as a* **Group/Club***, fill out the following information:*

  Name of contact student: _______________________________________

  Student ID of contact student: ___________________________________

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  Phone number of contact student: __________________________________

  Names of all students in the Group/Club making submission (below):

Eric Stubbs

Sustainability Awards Purpose Statement Essay

The ever-daunting surge of unrecyclable styrofoam products has been a nightmare to environmentalists worldwide. Not only does it not biodegrade, but it also leeches harmful chemicals into its surroundings, altering the natural cyclical processes of life and contaminating much of our food, water, and land. However, Stanford researchers have discovered an enzyme in the gut of the mealworm that can safely decompose styrofoam upon ingestion and excrete a biodegradable product. This was a scientific breakthrough, with the exception that, in place of the styrofoam, you would just have piles of mealworm feces! My experiment's goal was to find ways in which to exploit this new biodegradable fecal matter and put it to good use. So, I linked this with another problem in the world: the lack of fertile land in developing countries. Sadly, many poverty-stricken countries are not educated enough to realize that the fertile soil underneath recently deforested land is only good for a couple years at best; once they have used this land, they leave and start the process all over again, creating a nutrient-deficient desert and more clear-cut forests. In an attempt to solve this problem, I used the feces from mealworms that have been feeding on styrofoam and from mealworms that have been feeding on vegetables and mixed it with soil in two separate growing pots to raise mung bean plants. To my surprise, both groups of plants grew exactly the same with the exact same quality. Though it is still young in its experiential stage, I believe that with further research, this project could take off and change the way the poverty-stricken farmers use their land, while saving thousands of acres of forested area, and getting rid of our worldwide styrofoam problem all at the same time.

The Effect of Frass Produced by Styrofoam-Fed Mealworms on Mung Bean Plants

By: Eric Stubbs

Introduction

It seems as if society today cannot function properly without petroleum-based plastics. Ironically, something that takes millions of years to create often exhausts its one-time use in an instant, and is thrown away. However, nothing is ever truly thrown away; it is merely put out of sight. For example, the Great Pacific Garbage Patch is an accumulation of discarded trash in the middle of the Pacific Ocean, amassing an area larger than Texas (Angus 2014). The problem is that most of its foundation is made up of non-biodegradable substances, the most notorious of all being Styrofoam. This widely used and distributed product has made its mark in today's world as a staple commodity due to its wide range of uses and lightweight density. However, there is a downside to this wonder-product. Styrofoam, or polystyrene, is a toxic and non-biodegradable substance that accumulates in the environment while leaching out an array of chemicals that can biomagnify up a food web, back onto our dinner plates (Rochman et al. 2013). Its massive production contributes to this, for New York's sanitation department alone collected about 28,500 tons of polystyrene in 2014 (Hogue 2015). What is scarier is that this is only the amount of Styrofoam refuse generated from a small slice of the world - a world that readily consumes polystyrene. It may seem as if there is no hope in restoring the environment to its previous, pristine condition. However, studies by Yang and his colleagues (2015), in collaboration with Stanford University, have shown that some insects can safely digest and biodegrade Styrofoam due to microorganisms in their digestive systems. Insect waste, or frass, may offer a solution to these trash problems; however, the functionality of this Styrofoam excrement has yet to be tested, and I believe that it can be put towards a greater purpose. For this reason, I have decided to conduct a research project on the practicality of polystyrene frass as a fertilizer for food plants, namely mung beans. I predict that there is no difference in plant growth between plants that are fertilized with excrement from mealworms that have been feeding on carrots and bran and excrement from mealworms that have been feeding on Styrofoam. If the results are conclusive, this could be the solution to our extreme Styrofoam buildup in the environment, and perhaps one day man will have cleaned up his mess.

Methods

Five hundred mealworms were purchased from Rainbow Mealworms in Compton, California, and were roughly divided into two groups of two hundred fifty. The first group would be fed a diet of carrots and bran, while the second group was given Styrofoam from an insulated box, and a moist paper towel for liquids. The mealworms were given a three-week time allotment to consume as much food as they could and turn it into frass-fertilizer, which better known as insect waste. Two days before the end of the time slot, about one hundred mung beans were allowed to sit in water for twenty-four hours. After this, they were placed in a five-quart Sterlite bin lined with moist paper towel to allow them to germinate. The next day, sprouts had begun to form and I hand-selected fifty of the most promising looking beans to participate in the experiment. The mealworms were separated from the frass by using a spaghetti strainer, and the fertilizer was thoroughly mixed with approximately two inches of Edna's Best Potting Soil in two sixteen-quart Sterlite shoeboxes, one for the control group, the other for the experimental group. I evenly divided five rows in the soil, with five beans per row, which allowed the beans approximately two square inches of space. They were allowed natural sunlight as it was available throughout the day, and were sparingly watered in the morning and at night every day with a gardening mister for one week. A sixteen-quart Sterlite shoebox lid was placed over approximately half of each container to maintain humidity. After the one-week time allotment, a ruler was used to measure each plant starting from the base of the sprout to the tip of the stem.

Results

Data Table		
	Control Group Length (inches)	**Experimental Group Length (inches)**
1	3.3125	4.125
2	2.5625	2.125
3	1.1875	2.625
4	4.125	3
5	3.75	2.5
6	1.5	2.75
7	2.0625	4.3125
8	4	3.105
9	3.6875	3.4375
10	3.1875	3.375
11	0.4375	3.125
12	3.4375	3.625
13	5.125	2.9375
14	3.5625	3.875
15	4.4375	4.5612
16	3.25	3.105
17	4.1875	2.6875
18	3	2.8125
19	5.3125	0.875
20	1.875	2.5612
21	1.1875	3.4375
22	2.875	2
23	4.125	2.6875
24	3.75	4.8125
25	3.165	3.125

At the end of the 3-week period, I compared the average health of each mealworm colony to see if there were any negative side effects that came with eating Styrofoam. I did this by randomly selecting a few specimens from each group, then testing their responses to touch by gently squeezing them between my fingers; a normal mealworm would have wriggled around in an attempt to escape. I also watched their movements as a whole colony as they reacted to external stimuli such as shaking the bin they were being held in to disperse them; the average colony would respond by attempting to cluster around the corners of the bin. Lastly, I selected about fifty mealworms from each group and dropped them back onto their substrate; normal mealworms would have immediately started to burrow as soon as they landed on their bedding. The behavior of healthy mealworms has been observed throughout my childhood breeding insects to feed to my reptiles. As it turns out, the health of the Styrofoam group was identical to the health of the normal group. A week after the mung beans had been planted, the growth of the plants was very similar. For instance, all of the mung beans had sprouted, and most of them had already developed leaves. Once all of the measurements of the plants had been collected, the average of these values was found to be 3.1641 inches for the control group and 3.1032 inches for the experimental group.

A t-test was performed online using the lengths of each of the 25 individual plants in each group and the two-tailed P value was found to be 0.8393. Because the P value is greater than 0.05, there is no significant difference between fertilizer that was produced by mealworms that fed on Styrofoam and mealworms that fed on carrots and bran. The t-value was found to be 0.2038, and the degrees of freedom was 48. Also, the mean of the control group was 3.164060 and the experimental group was 3.103136, and the difference between the two is 0.060924.

Discussion

The results have shown that there is little difference between the fertilizer that was produced by mealworms feeding on Styrofoam and the mealworms feeding on carrots and bran. However, there are some notable differences between the overall quality and health of the plants grown. For example, the most extreme control group plant was able to reach a height of 5.3125 inches, whereas the tallest experimental group plant was about 4.8125. Though this is only a 0.5-inch difference, I should mention that there were many more plants around the five-inch range in the control group than the plants in the experimental group. Yet, the average plant length for both groups were extremely similar. This was due to more dramatic extremes in the control group, ranging from 1-5 inches, while the experimental group was mostly a constant 3-4 inches. Also, most of the plants in the experimental group stood perfectly erect, whereas many of the plants in the control group were slouched or leaning to one side. Kagata and Ohgushi (2011) state that the frass of the insect that produces it often contains the chemicals found in the substances they consume. It just might be worthwhile to conduct a study to see if the mealworms could have passed some of the chemicals from the Styrofoam into their frass, which found its way into the plants, causing them to stand more erect and grow at a slower rate. This could be an important study for two reasons: it could show that the chemicals found in Styrofoam have successfully found their way through the digestive systems of the mealworms and into the plants, demonstrating the dangers of Styrofoam usage and its lingering toxicity in the environment, or it could be used to an advantage in agriculture, causing plants that normally require a wire frame or vertical surface to grow upright, such as tomatoes, to grow upright on their own.

In an attempt to maintain humidity, I placed a plastic lid over half of each bin. Of course, the experimental group was unaffected by this, as most of the plant heights were uniform throughout. But, it seemed that the plants underneath the lid in the control group was where the dichotomy of sizes was produced. The lid covered three of the five rows of plants, and it seemed that the middle row and the row that was closest to the edge of the lid achieved the greatest heights, whereas the rows uncovered by the lid grew to average sizes. It is noteworthy to mention that the innermost row of plants did not do as well as any of the other rows of plants, covered or uncovered. I believe that this has something to do with its placement, being that it received the least ventilation as well as the most humidity. This leads me to believe that a slight amount of humidity and less exposure to the elements produces healthier mung bean plants. This also furthers my reason to believe that some of the chemicals in Styrofoam found its way into the plants, causing them to grow at a certain rate.

After testing the mealworms of the two colonies for reactivity towards external stimuli, I concluded that the health of both groups of mealworms was paralleled. This is consistent with the Stanford study on this, for they also say that the mealworms fed solely on Styrofoam were just as healthy as the mealworms fed on a normal diet (Yang et al. 2015). However, since the focus of either experiment was not the well being of the colony, the health of the mealworms was merely a speculation based on visual aspects. In order to find out consuming large quantities of polystyrene had any possible side effects, further in-depth biological research should be made. My main concern and skepticism about the health of the mealworms lies in the strong possibility that if the chemicals from the Styrofoam found its way into the plants, then it may have very well lingered in the bodies of the mealworms. Rochman and her colleagues (2013) have already done a study on the ingestion of plastics by fish and the harmful effects that can take place, including liver damage. Though an insect is a completely different animal than a fish, chemical poisoning is still in the realm of possibilities. If the mealworms were found to have traces of chemicals in their systems, then this knowledge could go hand-in-hand with the other research project I proposed above, compiling the evidence that Styrofoam chemicals are here to stay once unleashed into the environment.

Summary

The amount of Styrofoam in the environment is overwhelming. It is leaching out toxic chemicals that are altering natural ecosystems and destroying the balance of nature. But there is hope. Research done by Yang and his colleagues (2015) has shown that mealworms can safely biodegrade this petroleum product into excrement. In order to find a practical function for this left over waste produced, I investigated the excrement's viability as a fertilizer for food plants, namely mung bean plants. To test this, a group of mealworms fed on carrots and bran, and another group fed on Styrofoam. The excrement was then removed from both and mixed in separately with potting soil. Mung beans were then planted in the soil in different containers, and were observed for one week. When the plant heights were measured and compared, a P value of 0.8393 was produced, showing that there is little difference in the growth of the plants of either group.

However, there is some cause for worry for the plant health and viability due to the possibility of the mealworms transferring the chemicals in Styrofoam to the excrement, and thus found its way into the plants. Another research project will need to be conducted in order to determine if this is an actual concern.

Literature Cited

Angus, Ian. 2014. Plastic Plague. Monthly Review: 54-58.

Hogue, Cheryl. 2015. NYC Bans Expanded Polystyrene Food Containers, Opens Market to Alternatives. Scientific American.

Kagata, Hideki and Ohgushi, Takauki. 2011. Positive and negative effects of insect frass on soil nitrogen availability and plant growth. The Society of Population Ecology and Springer: 75-82.

Rochman, Chealsea M. 2013. Ingested Plastic Transfers Hazardous Chemicals to Fish and Induces Hepatic Stress. Scientific Reports: 1-7.

Yang, Yu et al. 2015. Biodegradation and Mineralization of Polystyrene by Plastic-Eating Mealworms: Part 1. Chemical and Physical Characterization and Isotopic Tests. Environmental Science and Technology: 12080-12086.

Yang, Yu et al. 2015. Biodegradation and Mineralization of Polystyrene by Plastic-Eating Mealworms. 2. Role of Gut Microorganisms. Environmental Science and Technology: 12087-12093.