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MEALWORM FRASS AS FERTILIZER:

Growth outcomes in Wisconsin Fast Plants

Introduction

In order to reduce the negative environmental impacts of agriculture, rearing insects on a large scale may offer a viable alternative protein source to other meat (Houben et al., 2020). As this practice grows, waste in the form of insect frass will be generated, which could potentially serve as an organic fertilizer.

The frass of herbivorous insects contains many essential nutrients for plant growth that are often found in commercial mineral fertilizers, including nitrogen, phosphorus, potassium, and calcium (Houben et al., 2020). In addition, frass contains chitin, a polysaccharide found in the exoskeletons of insects and the cell walls of fungi. Previous research suggests that chitin can increase plant growth, reduce plant pathogens and pests, and increase the quantity of beneficial microbes (Sharp, 2013).

The implementation of insect frass as fertilizer would help mitigate the impact of food shortages by providing healthier and more abundant crops, as well as facilitating the practice of rearing insects, which can serve as a protein source. Insect rearing is a relatively new and small-scale industry, meaning that the impacts of frass have not yet been well studied.

Introduction

Past studies show promising results:

- Houben et al., 2020 investigated the effects of mealworm frass as a fertilizer for barley plants. It was found that frass was equally effective at increasing plant biomass as an industrial NPK fertilizer with an equivalent nutrient level as the frass, and frass also has the potential to increase soil microbial activity

- Kagata and Ohgushi, 2012 examined the presence of cabbage moths (a common plant pest) and the impact that they and their frass can have on the growth of *B. rapa*. They found that the frass of insects that ate fertilized leaves had a higher nutrient content than those that ate unfertilized leaves (Kagata and Ohgushi, 2012). Also, *B. rapa* plant biomass increased when nitrogen-rich (high quality) cabbage moth frass was added to the soil, but biomass decreased when nitrogen-poor (low quality) frass was added (Kagata and Ohgushi, 2012).

Aims and Hypothesis

This study aims to answer the following question: How will the use of mealworm frass as a potential fertilizer affect overall plant health?

It is hypothesized that this use of mealworm frass will positively affect the growth of *B. rapa,* increasing the height, dry biomass, chlorophyll concentration, and number of buds, flowers, and seed pods per plant; findings of previous research suggest that insect frass is high in nutrients such as nitrogen, phosphorus, calcium, potassium, and chitin, which are beneficial for plant growth (Houben et al., 2020, Lee et al., 2019, Kagata and Ohgushi, 2012). In addition, this study investigates anecdotal accounts of increased seed production when plants are raised on frass compared to other types of fertilizer.

Methods

48 Wisconsin Fast Plants were grown in a light box (24 plants in the control group and 24 plants in the frass group). Each pot was filled with 1/4 cup of Miracle Gro Potting Mix. For plants in the frass group, 1/4 teaspoon of mealworm frass was added and mixed in evenly.

On day 17, the number of flowers/buds was counted for each plant. On day 20, the number of seed pods was counted, and on day 23, plant height was measured.

On day 24, twelve plants from each group were randomly selected. These plants were dried in a laboratory oven at 70°C for 48 hours and then weighed using an electronic balance.

Image: plants shown inside light box

Methods Continued

The remaining twelve plants in each group were used to measure chlorophyll concentration. Three leaf samples of 250 mg were taken from each group. Each leaf sample was macerated with 10 mL of 80% acetone using a mortar and pestle. The resulting solution was centrifuged at 3000 rpm for 10 minutes. The supernatant chlorophyll solution was made up to 15 mL using 80% acetone. Next, this solution was poured into a cuvette. The PASCO-CI-6747 Colorimeter was used to record percent transmittance for the chlorophyll solutions at the blue wavelength (460nm).

Data for all variables was averaged for the two groups, and standard deviation and standard error were calculated. Two-Sample t-Test procedures were carried out using Excel to compare the sample means of the two groups at the alpha=.05 significance level.

Image (top): cuvette with chlorophyll solution. Image (bottom): materials for measuring chlorophyll using colorimetry.

Photos – Methods

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1: Mature flowering Wisconsin Fast Plants. A seed pod is visible on the closest plant. **2**: Plants shown in foil weigh-boats in the drying oven before biomass was measured. **3**: A cuvette containing chlorophyll solution is shown in the colorimeter.

Results

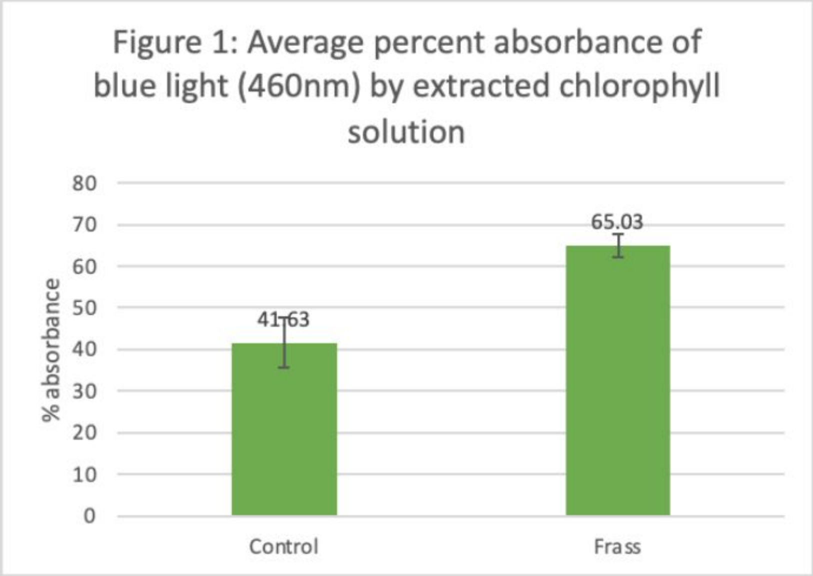

Table 1: Average percent absorbance of blue light (460nm) by extracted chlorophyll solution	Control	Frass
Average (% absorbance)	41.63	65.03
Standard Deviation	10.37	4.79
Standard Error	5.99	2.77

Two-Sample t-Test: ***P*=.02**
df = 3 t-statistic = -3.55

Values shown represent averages of the 24 plants in each group. The p-value of <.001 indicates that the average number of buds/flowers for the frass group was significantly higher than for the control.

Results

Average above-ground dry biomass is significantly higher for the frass group than for the control.

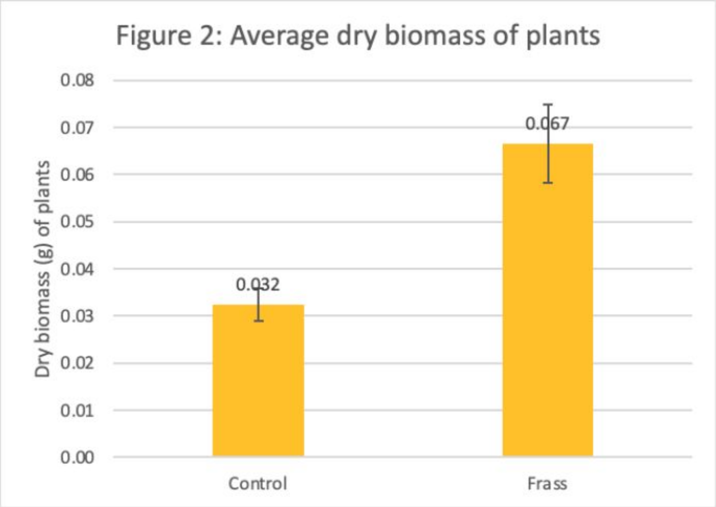

Table 2: Average dry biomass of plants	Control	Frass
Average (grams)	0.032	0.067
Standard Deviation	0.012	0.029
Standard Error	0.004	0.008

Two-Sample t-Test: ***P*=.001**
df = 19 t-statistic = -3.56

There is no statistically significant difference in height between the two groups.

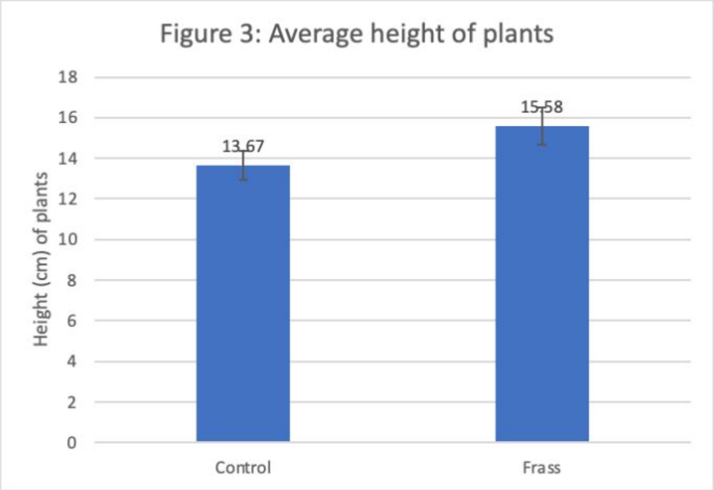

Table 3: Average height of plants	Control	Frass
Average (cm)	13.67	15.58
Standard Deviation	3.46	4.49
Standard Error	0.71	

Two-Sample t-Test: ***P*=.0**
df = 43 t-statistic

Results

Average number of buds/flowers per plant is significantly higher for the frass group than for the control.

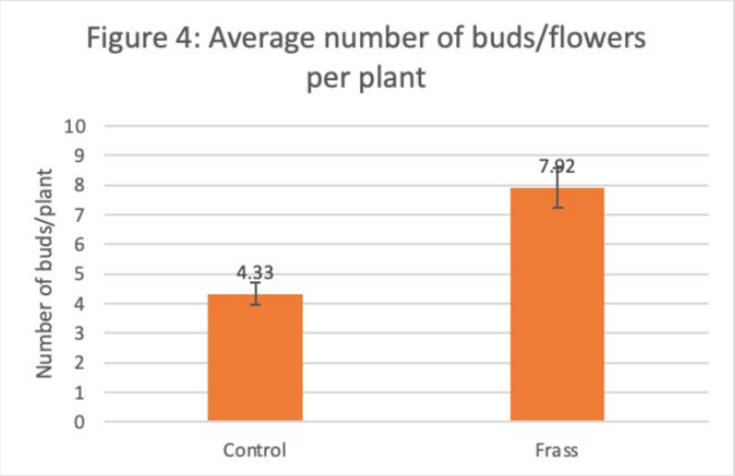

Table 4: Average number of buds/flowers per plant	Control	Frass
Average (number of buds/ flowers)	4.33	7.92
Standard Deviation	1.75	3.27
Standard Error	0.36	0.67

Two-Sample t-Test: ***P*<.001**
df = 38 t-statistic = -4.61

Average number of seed pods per plant is significantly higher for the frass group than for the control.

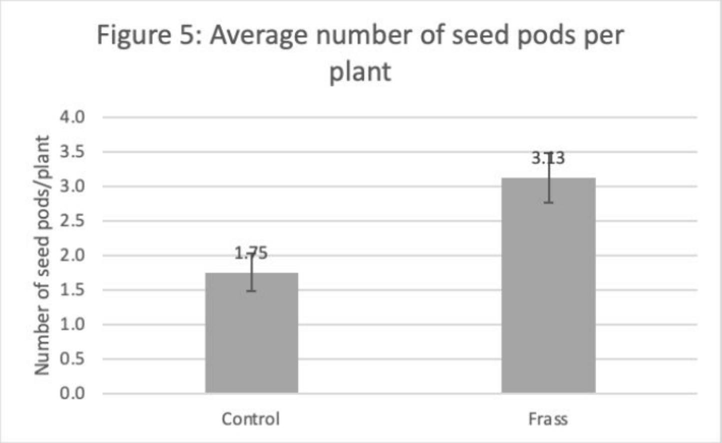

Table 5: Average number of seed pods per plant	Control	Frass
Average (number of seed pods)	1.75	3.13
Standard Deviation	1.36	1.75
Standard Error	0.28	0.36

Two-Sample t-Test: ***P*=.002**
df = 43 t-statistic = -3.04

Analysis

The hypothesis was supported by the findings of the study. Average values for chlorophyll concentration, dry biomass, number of buds/flowers, and number of seed pods were all significantly higher for the frass group than for the control group. However, there was no statistically significant difference in average height between the two groups. Statistical significance was evaluated at the alpha=.05 level using a Two-Sample t-Test.

Results indicate that frass is indeed an effective fertilizer compared to potting mix alone. Plants grown with frass added to the soil were healthier overall, likely due to higher nutrient availability of nitrogen, phosphorus, potassium, and calcium.

It is likely the control plants were more nutrient deficient than the frass plants. This can cause stunted growth, yellowing of leaves, reduced chlorophyll production, and reduced crop yield (Morgan and Connolly, 2013).

Future Directions

- Explore the potential of increased disease resistance from frass fertilizer by measuring chitinase expression in plants exposed to insect frass (which is high in chitin).
- Measure the impact of frass fertilizer on nutrient and bioactive compound content in *B. rapa* and other vegetables.
- Expanding into different plants such as agricultural crops, to see if effects vary.
- Test different concentrations of frass to find an optimal amount, compare it to different commercial chemical and organic fertilizers.
- Explore logistics of implementing such a program by contacting farmers, calculating prices and travel costs, etc.

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