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Article

Analysis of biofertilization impacts on *Pisum sativum*

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SUMMARY

Nutrient degradation in soil is becoming a prominent agricultural issue due to widespread unsustainable farming practices such as overgrazing and over-cultivation. As agriculture is such an integral aspect of society, developing methods to increase crop yield is imperative for feeding the future generations of humankind. The United States spends billions of dollars each year to combat nutrient loss in soil, but soil productivity and crop yields are still decreasing. In this study, we explored the various effects of three different produce-based biofertilizers on pea plant growth, using red apple, pear, strawberry, and control treatments. To apply the fruit biomatter, we peeled, powdered, and mixed the fruit with distilled water to form a solution. We watered the pea plants, *Pisum sativum*, with the different solutions for the duration of the 18-week experiment. We hypothesized that the application of fruit biomatter would increase the growth of pea plants, with the application of strawberry biomatter having the most significant effect due to strawberries containing a higher nutrient content compared to pears and apples. Upon analysis, we observed that the fruit biomatter with strawberry peels significantly increased the growth of the pea plants, while the application of red apple biomatter and pear peel biomatter had no significant effect. The application of strawberry biomatter could prove to be an effective way to increase plant growth in commercial agriculture. Further research is needed to determine if the application of apple and pear biofertilizers increases the plant growth of *Pisum sativum*.

INTRODUCTION

Across the world, the demand for food is increasing, while the capacity to produce food is decreasing (1). Nutrient loss contributes from 50% to 75% of the decrease in soil quality worldwide (2). The United States spends $20 billion annually to combat nutrient deficiencies, and yet soil productivity is still decreasing (2). In the state of Michigan, nutrient degradation of the soil due to over-farming is increasing, leading to a decrease in the soil quality, and a subsequent decrease in the quantity of the crops produced (3). This is a major concern as it may lead to desertification and a decline in food production, which negatively impacts the human population. In Michigan, corn crop yields have decreased by 21% over the last fifteen years due to nutrient degradation, causing a rise in food instability in the region (2).

The purpose of this experiment was to find a way to replenish nutrient loss in soil using organic produce grown locally in Michigan: red apples, pears, and strawberries. Multiple previous studies have shown a correlation between fruit peel application and increased plant growth and soil quality (4). One such study, done by researchers in India, showed how the application of powdered orange, lime, and banana peels increased the growth of fenugreek plants (5). Another study, done by researchers in Iraq, found that the application of orange and banana peels had a positive effect on the growth of chickpea plants (6). There is, however, limited research into the specific effects of strawberries, pears, and apples on plant growth.

Here, we aimed to expand on this research to determine if the application of these specific types of fruit peels has any effects on plant growth. Due to the nutrients found in fruit peels, their application to the growing environment of plants may be beneficial to the soil quality, overall growth, and yield of the plants (4). *Pisum sativum,* commonly known as pea plants, was selected for this experiment due to its fast growth and germination rate. Additionally, pea plants are indigenous to Michigan (7).

We hypothesized that the application of fruit biomatter would increase growth in pea plants, with the application of strawberry biomatter producing the most growth. Strawberries are considered to have notably higher phosphorus, nitrogen, and potassium content than red apples and pears, which are the primary components of the fruit biomatter that impact the plant growth when applied to the plant's growing environment (8). The variables measured in this experiment were the plant height, the number of leaves per plant, and the dry weight. We aimed to ascertain whether the application of fruit biomatter increased the overall growth of the pea plants, as well as which type of fruit peel would lead to the highest growth. We found that the application of strawberry biomatter significantly increased plant growth, while the application of apple and pear biomatter did not have a significant effect. Thus, the application of strawberry biomatter could be effective in combating nutrient depletion in soil.

RESULTS

This study examined the effects of pear, apple, and strawberry fruit biomatter on plant growth. For each treatment, 24 plants were grown, and their height and number of leaves was measured and recorded for a period of 28 days. After the growth period was over, each plant stem was severed even with the soil line and dried for 48 hours to determine dry weight. In total, 96 plants were used in this experiment over

the 18-week period.

The height of the plants treated with strawberry was significantly taller than the control group (1-tailed t-test, p = 0.014). There was no notable effect of the apple treatment on the plant height, as the average height of the apple group was approximately the same as the control group (1-tailed t-test, p = 0.303) (**Figure 1**). There was also no effect of the pear treatment on plant height (1-tailed Mann-Whitney U, p = 0.401).

The number of leaves of the plants treated with the strawberry biomatter was found to be significantly greater than the control group (1-tailed t-test p = 0.038) (**Figure 2**). There was no significant effect of the apple treatment on the number of leaves a plant had (1-tailed t-test p = 0.486). Also, there was not a notable effect of the pear treatment on the number of leaves (Mann Whitney U, 1- tailed p = 0.507).

The dry weight of the plants treated with strawberry biomatter was found to be significantly greater than the control group (1-tailed t-test p = 0.013) (**Figure 3**). There was no obvious effect of the apple treatment on dry weight (1-tailed t-test p = 0.790). Also, there was no significant effect of the pear treatment on dry weight (Mann Whitney U, 1- tailed, p = 0.812).

The application of strawberry biomatter was the most effective of the treatment types and produced statistically significant results with all variables measured compared to the control group. The average amount of leaves for the plants treated with the strawberry biomatter was consistently higher than the control group for the entirety of the 28-day growth period (**Figure 2**). The average dry weight of the strawberry group is 0.068 grams, while the average dry weight of the control group is 0.043 grams (**Figure 3**). The strawberry group had statistically more leaves and a greater dry weight than the control group, while the apple and pear groups did not have significant results regarding either dry weight or the number of leaves. These trends can also be observed in **Figures 2** and **3**. This indicates that the strawberry treatment increased

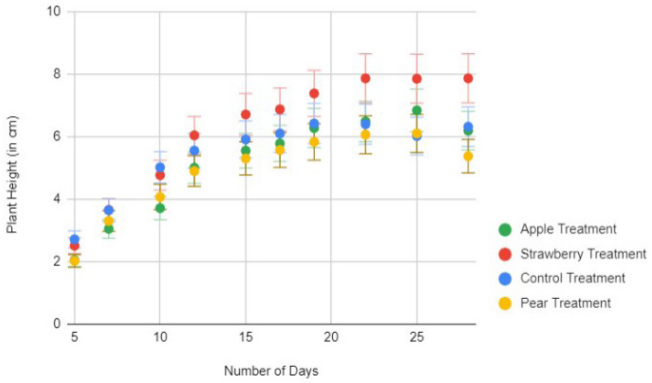

Figure 1. Average plant height. Dot graph showing the average plant height in cm. Plants were either grown under control conditions (n=24), or with an apple (n=24), pear (n=24), or strawberry (n=24) powder additive. Error bars represent the standard error in the data. There was no significant difference between the plant height of the apple treatment compared to the control (1-tailed t-test, p = 0.303), nor the pear treatment compared to the control (1-tailed Mann Whitney U p = 0.401) but there was found to be a significant difference between the plant height of the strawberry group and the control (1-tailed t-test p = 0.014).

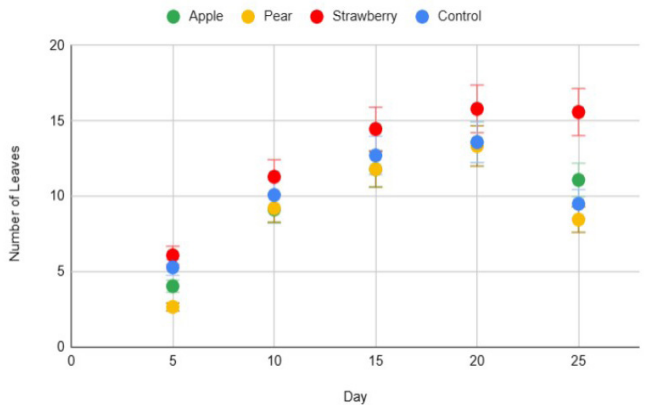

Figure 2. Average number of leaves per plant over three trials. Line graph showing the average number of leaves per plant. The number of leaves was measured every five days until day 25, and grown under either under control conditions (n=24), or with an apple (n=24), pear (n=24), or strawberry (n=24) powder additive. Error bars represent the standard error in the data. There was no significant difference between the number of leaves per plant for the apple treatment compared to the control (1-tailed t-test, p = 0.486), nor the pear treatment compared to the control (1-tailed Mann Whitney U p = 0.507) but there was found to be a significant difference between the plant height of the strawberry group and the control (1-tailed t-test p = 0.038).

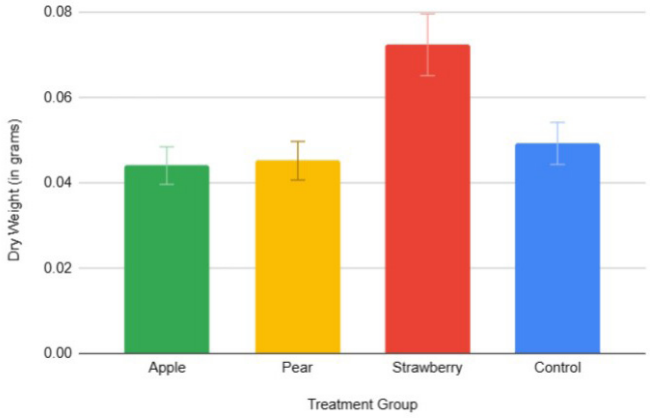

Figure 3. Average dry weight per plant over three trials. Bar graph showing the average dry weight in grams after 28 days of growth. Plants were either grown under control conditions (n=24), or with an apple (n=24), pear (n=24), or strawberry (n=24) powder additive. Error bars represent the standard error in the data. There was no significant difference between the plant height of the apple treatment compared to the control (1-tailed t-test, p = 0.790), nor the pear treatment compared to the control (1-tailed Mann Whitney U p = 0.812) but there was found to be a significant difference between the plant height of the strawberry group and the control (1-tailed t-test p = 0.013).

plant growth as it significantly increased plant height, plant dry weight, and number of leaves, while the other two treatments did not show any clear increase in plant growth.

DISCUSSION

This research was conducted to determine the effectiveness of fruit biomatter as a potential crop fertilizer. We hypothesized that the application of fruit biomatter would increase the overall growth of pea plants. The findings of this study showed that the use of strawberry biomatter on pea plants increased the height and overall growth of the plants. There was no significant effect on plant growth when apple and pear peels were added. This was surprising because apple and pear peels both contain potassium, an element that has been shown to increase plant growth by stimulating photosynthesis and increasing the rate of protein growth (9). We anticipated that strawberries would have a beneficial impact on plant growth, as similar fruits have been shown in past studies to improve plant growth (10). The results of this experiment may or may not be replicated with other plants, as distinct species of plants react differently with the antioxidants and minerals present in fruit peels.

Strawberries are also known to contain potassium, nitrogen, and phosphorus, which are nutrients that could correlate with plant growth (8). Nitrogen is essential for the development of protein within a plant, phosphorus helps stimulate photosynthesis, and potassium allows for a higher threshold for resistance to disease within a plant (9). Apples and pears contain these nutrients but have a lower potassium and phosphorus content than strawberries, potentially explaining why strawberries had a greater impact on plant growth than the other fruits tested in the study. On average across all apple varieties, one cup of chopped apple contains 134 milligrams (mg) of potassium, one cup of chopped pear contains 162 mg of potassium, and one cup of sliced strawberries contains 233 mg of potassium. A similar trend can be observed with the phosphorus content of these fruits: one cup of apple contains 13.75 mg, one cup of pear contains 16.80 mg, and one cup of strawberries contains 36.48 mg (11).

Our experiment was limited by availability of space and accessible materials. Growing 96 plants requires a large amount of space, and all plants had to fit on a 20.75 by 48-inch seedling heat mat, which may have impacted the results. Another problem was buying large volumes of organic fruits was expensive, especially strawberries and pears. Thus, careful planning and attention was paid to maximize available materials.

If this experiment were to be replicated, watering the pea plants less frequently would be recommended. By the end of each of the trials, many plants displayed typical signs of overwatering such as brown, limp leaves, and soil that was regularly wet to the touch (12). There were also some cases when the surface of the soil started molding, likely due to the excess amount of fruit powder build-up. This could be mitigated by increasing the ratio of water to fruit powder to decrease the amount of excess fruit powder.

The application of strawberry biomatter could be a suitable method of combating nutrient depletion in soil. However, a comparison between strawberry peels and commercially available fertilizer is needed to see if strawberry peels are viable alternatives to conventional fertilizers. It may not be economically practical on a commercial scale as strawberries are expensive and the process of application is tedious. Further research is needed to determine less expensive and more efficient ways to apply fruit matter to plants.

MATERIALS AND METHODS

Three distinct types of produce-based treatments were applied to pea plants: strawberry, apple, and pear peels. First, the fruits were purchased from local vendors. The fruits were rinsed with distilled water and peeled using a conventional potato peeler. The peels of fruit were laid out on parchment paper and placed on a 20.75 by 48-inch seedling heat mat. All the peels were spaced apart by at least ¼ of an inch and grouped by fruit type to avoid amalgamation. After the fruit peels had dried for approximately 48 hours, a sanitized mortar and pestle was used to finely grind each separate fruit peel type, taking care not to leave any large pieces of peel in the powdered substance. Once each type of peel was powdered, it was mixed with distilled water to form a solution with a ratio of ¼ teaspoon fruit powder per 50 mL of water.

The four conditions for this experiment were apple treatment, pear treatment, strawberry treatment, and the control group. To achieve an adequate sample size, each group consisted of eight pea plants, and the experiment was repeated three times. We filled each container with approximately 1/2 cup of Miracle Gro Potting soil. Two pea seeds were planted at a one-inch depth in every container, as per the planting instructions. Immediately after the seeds were planted, the seeds were watered with 30 mL of the appropriate powder-water solution treatment. Each plant was then watered three times a week with 20 mL of the powder-water solution that corresponded with the treatment type for a total period of 28 days. The control group was watered with unmitigated distilled water for the duration of the experiment. The 28-day period for growth was chosen to maximize the number of trials that could be performed over the 18-week duration of the experiment. All the plants in this experiment were consistently exposed to the same amount of sunlight, water, and heat.

To measure the overall growth of each plant, the height (cm), number of leaves, and dry weight (grams) were measured. The height of each plant was measured four times each week, while the number of leaves was measured once per week. The data on height and number of leaves was recorded. The dry weight of the plants was measured after the 28-day growth period had finished. To measure dry weight, each plant stem was severed at the soil line, laid on parchment paper, and placed on a drying mat for a period of

72 hours. They were then weighed using a gram scale and the dry weight was recorded. Measuring the yield of the pea plants was impossible within the time limit of this study, as it sometimes takes months for the plants to flower and produce pods. For each group, 24 plants were grown and measured over a period of 28 days. In total, 96 plants were used in this experiment during the 18-week period.

Upon growing 24 plants for each treatment group, the strawberry, apple, and control treatments displayed a normal distribution. Thus, a 1-tailed t-test for two independent means was performed to compare both the strawberry and apple treatments to the control group. The pear treatment data did not display a normal distribution, so a 1-tailed Mann-Whitney U-Test was used to determine significance. All the statistical analyses were computed using the Social Science Statistics Calculator. The alpha value for the three hypotheses comparing each fruit treatment to the control group was 0.05; a result was considered significant if the *p*-value was found to be less than 0.05.

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