Determining how compost composition and pH affect plant germination and growth

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Abstract

Approximately 30-40% of our food supply is wasted, causing environmental challenges when it decomposes. Composting offers a solution to this issue by recycling organic material into soil-enriching material. This experiment examined how different compost compositions aided or hindered the germination and growth of green bean seeds/seedlings. Compost mixtures were prepared using organic potting soil combined with food scraps of varying acidity and incubated for 10 days before planting green bean seeds. After a 16 day growth period, seeds in acidic compost showed the highest germination and growth rates, while the salty condition exhibited the least growth. The soil pH remained relatively consistent throughout the course of the experiment but varied slightly during incubation and growth periods. These findings suggest that compost composition, particularly its pH and nutrient content, significantly influences plant germination and growth. This pilot study highlights the potential of optimizing compost mixtures to enhance agricultural productivity.

Introduction

In the United States today, the US Department of Agriculture (USDA) estimates food waste is between 30–40 percent of the food supply, translating to about 133 billion pounds and (from 2010 estimates) $161 billion in food losses annually (1). Large amounts of wasted food lead to environmental issues as they decompose, requiring solutions to help with sustainability and minimizing our ecological footprint.

Composting is an alternative solution that can not only reduce waste but also create valuable fertilizer for plant growth. Composting is “the process of recycling organic materials into an amendment that can be used to enrich soil and plants” (1). It involves understanding and balancing the chemistry behind key elements present in air (oxygen, nitrogen, carbon, and hydrogen), elements found in food scraps (carbon, nitrogen, sulfur, iron, potassium, and phosphate), and microbes that perform critical metabolic reactions to process the debris (2).

While composting is not a new concept, significant barriers remain to make it an economically scalable solution. While there are general guidelines for the balance of green (nitrogen-rich) and brown (carbon-rich) materials, specific optimal ratios may vary based on factors such as local conditions, types of waste, and composting methods (3). Processed foods with high levels of preservatives or additives, for example, may decompose more slowly compared to natural, unprocessed foods.

Microbially, while it is known bacteria play a pivotal role in breaking down complex fibers and performing functions such as fixing nitrogen, it’s still unclear what their ideal growth environment needs are. For example, bacteria need nutrients such as fiber and sugars to grow & multiply, balanced salts to prevent them from getting dried out, and a neutral pH to function optimally (4). As a result, composting demands careful attention to moisture, time, and microbial activity.

This study tested whether different compositions of compost mixtures influence fluctuations in pH and moisture, and ultimately how these variables modify plant growth. Using green bean seeds, germination rates and overall growth of seedlings were monitored between different compost mixtures consisting of garden soil mixed with acidic food scraps (limes and lemons), neutral food scraps (pasta and bread), salty foods (seaweed, olives, cheese), or sweets (doughnuts). Interestingly, after 16 days of growth, acidic compost mixtures led to faster germination and more overall growth compared to salty compost, which exhibited the least growth.

Methods

Seeds & Source of Soil: Organic potting mixture (Hoffman) was used as the base medium for all compost mixtures. Specifically, 363 grams of soil were placed in plastic containers and mixed with 100 mL of water.

As shown in **Figure 1**, four independent compost mixtures were created: acidic, neutral, salty, and sweet conditions. The acidic compost consisted of peeled limes and lemons. The neutral compost consisted of boiled string pasta and mashed white bread. The salty compost consisted of used separated dried seaweed, pitted olives, and mashed American cheese. The sweet compost consisted of a mashed doughnut.

For each compost mixture, approximately 90 grams of the components listed above were added to the soil and mixed by hand. The resulting mixture was placed into a plastic container and was allowed to incubate in the dark for 10 days prior to adding the seeds.

After compost incubation, six green bean seeds (Mountain Valley Seed Company) per compost condition were placed in the soil approximately one inch down from the surface. Each container was monitored closely over an incubation period of 10 days and for a growth period of 16 days.

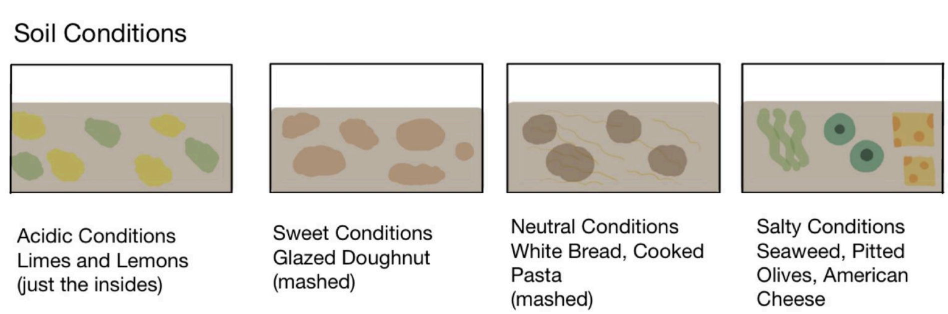

Figure I. Schematic depicting each compost mixture (prior to adding seeds)

Measuring soil pH: Soil pH was measured before & after the compost incubation period, and following the growth period. For this, 10 grams of soil from each condition was added to 40 mL of water. Once the four cups were filled, the soil was mixed around and allowed to settle. Litmus pH strips (ThinkPrice) were dipped into the solution to measure the pH of each condition as seen in **Figure 2**.

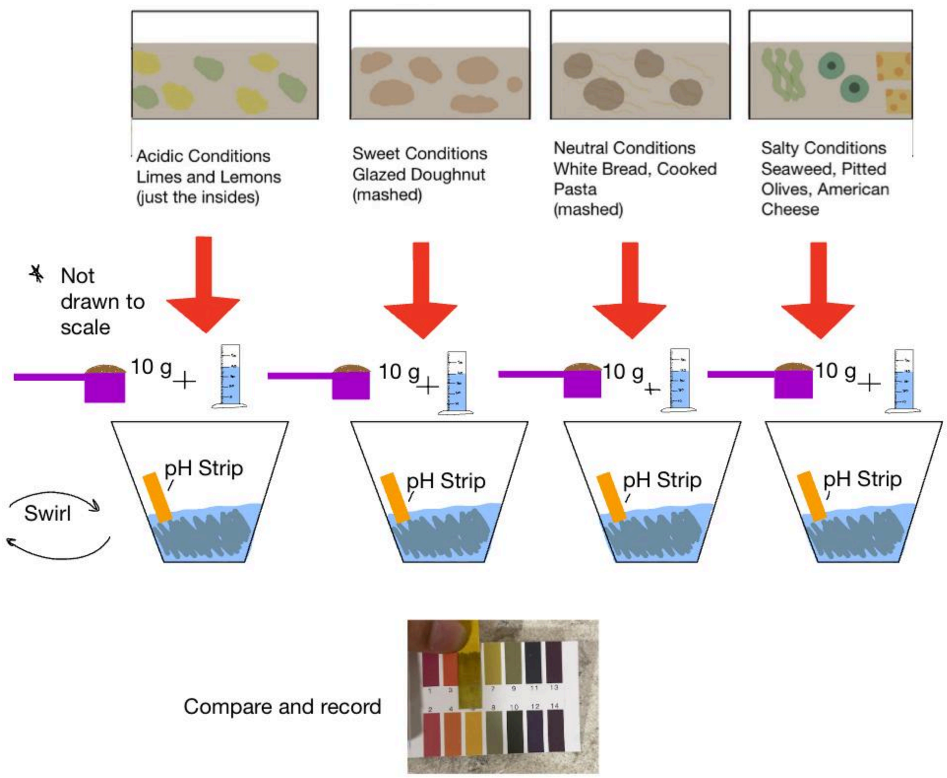

Figure II. Diagram depicting how the pH was measured for each soil composition. pH measurements were conducted pre- & post- compost incubation and before adding the seeds.

Growth conditions

Watering

Following the ten-day compost incubation period, approximately 30mL of water was added to each soil-compost mixture prior to adding the seeds. No additional water was added until germination was observed. After germination, the soil was watered daily to keep the mixture moist.

Light cycle

Compost incubation period – All soils were kept in the dark for 10 days at room temperature.

Seed incubation period – Planted soil mixtures were kept at room temperature near a window where they got sufficient sunlight (8 hrs) during the day.

Cover vs. no cover

Compost incubation period – A hard plastic cover was placed on the four soil conditions to prevent moisture from leaving the containers.

Seed incubation period – For seedling growth, the hard plastic cover was replaced with thin plastic sheets to allow adequate airflow.

Germination determination and growth measurements: To determine germination rates and growth measurements, pictures were taken daily of the plants. Once the growth period was over, each plant was gently taken out of the soil and measured with a ruler from base of the longest root to tip of the seedling to determine growth per soil condition.

Results

In this pilot experiment, differences in seedling germination and overall growth rates were observed when different compost mixtures were used as a growth medium. As shown in **Figures 3/5/6**, seedlings in the acidic compost conditions had the most growth, followed by sweet, neutral, and salty conditions after sixteen days.

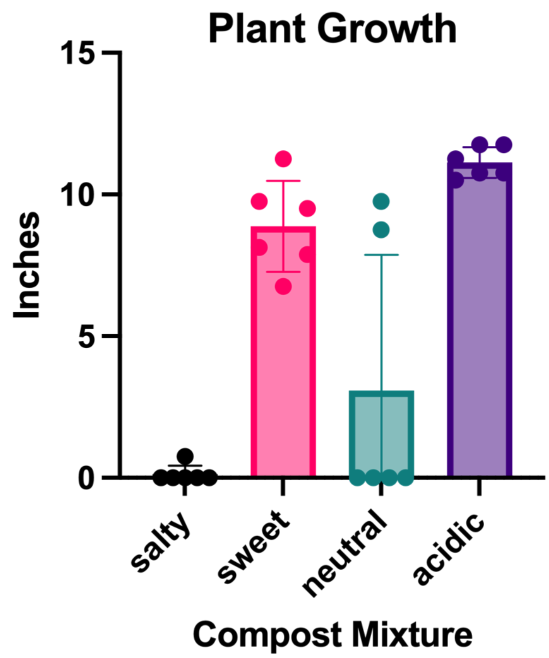

Figure III. Growth of plants in each compost mixture after sixteen days. Each dot represents one plant; bars and error bars represent mean and standard deviation.

In terms of the soil itself, all compost mixtures were left in the dark to incubate for ten days. During this period, white fuzz was observed on the surface of all of the soils, most notably in the salty and acidic conditions. This fuzz spread quickly across the entire container over the ten days. Prior to adding the seeds, each mixture was remixed in order to evenly distribute the fuzz and nutrients. Interestingly, no additional fuzz was observed during the seed germination or growth periods.

Notably, differences in water saturation were observed amongst the different compost mixtures. During the growth period while the plants were being watered, the neutral and sweet soil conditions did not allow for rapid water absorption. Most of the water would pool on the surface and the overall container often did not need to be watered for several days.

Figure IV. Image depicting fuzz that grew on all of the compost mixtures during the compost incubation phase of the study.

Regarding changes to pH, the pH of the salty soil conditions remained neutral (pH 7) throughout both the compost incubation period and the seed growth period. The salty conditions fluctuated between pH 7 and 8, but returned to a pH of 7 by the end of the growth period. Surprisingly, the pH of the acidic condition increased from 6 to 9 during the seed incubation period, but fell back down to a neutral pH of 7 once the experiment was over. Finally, the pH of neutral conditions started at 9 and fell to a pH of 7. Overall, while some fluctuations in pH were observed, the pH generally stayed constant amongst the four conditions.

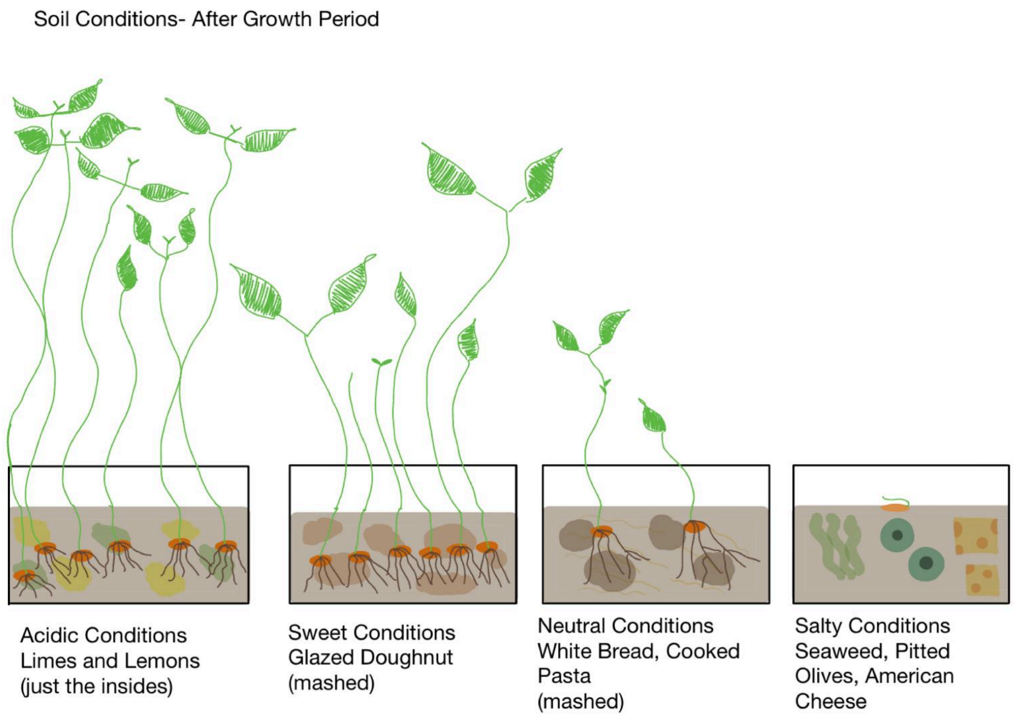

Figure V. Diagram depicting growth of plants in different soil conditions

Figure VI. Image of acidic (left) and neutral (right) compost plant growth

Discussion/Conclusion

This pilot experiment aimed to test how different compost mixtures impact plant germination and growth. For this, various compost mixtures consisting of acidic, sweet, neutral, and salty conditions were created. As described above, the acidic compost condition led to the most growth after 16 days of incubation. The other compost mixtures had less growth, with the neutral and salty conditions having little to no growth. Though this was only a preliminary study, these results might suggest lower pH containing foods may serve as a source of major nutrients or trace elements needed by plants to thrive. Alternatively, these results may suggest that neutral/salty compost mixtures are inhibitory to plant growth. In other words, there may be harmful nutrients in those compost mixtures that prevent adequate plant germination independent of changes to soil pH. Future studies can control for this by including a soil condition in which no compost is added.

Overall, this experiment highlights some major challenges in testing how various compost mixtures impact germination and growth rates. During earlier pilot experiments using lima beans, no growth in any condition was observed. While there was a notable shift in the pH of the neutral and sweet compost soils (they became more acidic), the soil in these earlier studies did not contain fertilizer and did not seem like the correct soil to be using for this overall study. Therefore, in a followup pilot experiment (the one described in this study), organic potting soil along with different seeds were used.

Interestingly, during the compost incubation period, a layer of white fuzz appeared on top of the acidic and salty conditions. This white fuzz looked similar to mold, and most likely grew during the incubation period due to the moist and dark conditions. Once the container caps were taken off, the mold slowly receded as the mixtures were put into sunlight and were watered everyday.

As this was only a pilot study, changes to future studies may include soaking seeds for a day prior to beginning – soaking seeds allows them to germinate faster as the water hydrates them. In terms of what variables could be tested, a future study might assess whether more or less acidic pH is most beneficial for plant growth. The results of this research could then be used on farms that compost by showing them which type of compost will have the best plant growth for their crops.

Conclusion

Overall, composting is an alternative waste management practice that efficiently tackles food waste issues while producing nutrient-rich fertilizer. By diverting organic waste from landfills, it may minimize environmental impacts. Understanding the chemistry involved, such as why certain foods decompose faster, and recognizing essential nutrients in composts could increase the overall utility and benefit of the process. Composting not only reduces waste but also promotes soil health and plant growth, playing a vital role in sustainable agriculture.

References

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