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Article

Effect Of SMC On The Growth Of Bean, Cherry Tomato And Roma Tomato Plant

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SUMMARY

With a growing demand for organic fruits and vegetables, backyard gardening is becoming increasingly popular. We performed this experiment to determine the effect of Spent Mushroom Compost (SMC) in varying proportions of the soil on optimizing plant growth. We selected bean, cherry tomato, and Roma tomato plants for this study due to their popularity in gardening. Five growth media were prepared with different combinations of soil and SMC such as 0% SMC, 30% SMC, 50% SMC, 70% SMC, and 100% SMC. We hypothesized that the growth media with 30% SMC would optimize plant growth based on evidence from past research showing that moderate amounts of SMC best support the health of the plants. We used the germination rate, plant height, number of leaves, and survival rate as a measurement. We found that SMC increased plant growth of cherry tomato, Roma tomato, and bean plants. We showed that the hypothesized growth media with 30% SMC optimizes seed germination, plant height, number of leaves, and survival rate compared to other combinations of growth media. Our research suggests that SMC is a useful alternative for conventional fertilizers.

INTRODUCTION

Growing organic vegetables and fruits is healthy for individuals and for the environment. Fresh fruits and vegetables are healthier than canned, as they have less chemical exposure and the content of vitamins is higher, especially in phytochemicals, antioxidants, vitamin C, vitamin A, and folate (1). Gardening helps improve individual health, save money on groceries, and provide good exercise and stress relief (2). When growing organic fruits and vegetables, pesticide usage can also be minimized. As the usage of organic vegetables and fruits in gardening is increasing, there is a need to find an alternative source of organic fertilizers to increase plant growth and production. Therefore, we decided to research a potential organic fertilizer, Spent Mushroom Compost (SMC), to provide plants with these benefits.

Mushroom compost is a type of slow-release, organic plant fertilizer (3). Mushroom compost, also called Spent Mushroom Substrate or Spent Mushroom Compost, is suitable for a variety of plants. SMC can be used in pots, gardens or on lawns. This compost is generally made up of a mix of hay, straw, corn, and horse manure. Gardeners commonly use SMC as a soil amendment due to its ability to increase the water-holding capacity of soil, which reduces the amount of water the plants need. We chose Beans (Phaseolus vulgaris), cherry tomato, and Roma tomato (Solanum lycopersicum) plants for this study due to their popularity in gardening cultivation and their similar requirements for growth conditions.

Previous research has found that the application of SMC will increase plant growth (4). However, it is unclear which exact proportions of SMC and soil will maximize tomato and bean plant growth. As a result, for this project we tried to find the SMC quantity that best supported plant growth. Using too much SMC can cause the plants to soak up too much water, thereby resulting in the plants' death. But in moderate amounts, such as 30% SMC safely enriches soil and provides plants with nutrients. We hypothesized that bean, cherry tomato, and Roma tomato plants cultivated in growth media with 30% SMC would have the most significant growth in seed germination, plant height, number of leaves, and survival compared to other growth media ratios. For comparative purposes, we also tested the following ratios: 100% soil, 30% SMC, 50% SMC, 70% SMC, and 100% SMC. The objective of this study was to find the SMC portion mixed with soil that best supports vegetative growth. By identifying the precise conditions under which SMC leads to improvement in plant growth, our research can benefit individual gardeners, farm-to-table growing, and sustainable farming more generally.

RESULTS

We tested the effects of various SMC proportions on plant growth by measuring the germination percentage, plant height, the number of leaves per plant, and the survival rate for bean, cherry tomato, and Roma tomato plants, using five different growth media over the span of six weeks as shown in Figure 1 shows the growth stages of the plants from week 3 to week 6. The addition of SMC led to consistently higher rates of germination and survival for all three types of plants (Table 1). The percentage of seeds that germinated proved to be 100% in all growth media except the medium that received no SMC at all and one additional medium for Roma tomato, 70% SMC. The growth media with 30% SMC showed 100% germination for all three types of seeds, a performance matched only by 100% SMC.

Plant Height: Overall plant height was significantly improved by the addition of SMC to the soil for all three types of plants

at a statistically significant level of p<0.5 (Figure 2). Bean plants grown in the 30% SMC growth media had an average height of 35cm, while those grown in 0% SMC reached only 10cm. The cherry tomato plant height was also significantly improved by the addition of SMC to soil. The cherry tomato plants grown in the growth media with 30% SMC had an average height of 9cm while plants grown in the 0% SMC growth media only reached 2.32cm. Roma tomato plants grown in the 30% SMC growth media had an average height of 7cm while those grown in only SMC or only Soil growth media reached just 2.5cm (Table 2).

Number of Leaves: For all three types of plants, we found that adding SMC to the soil increased the number of leaves (Table 2). For the cherry tomato plants, we found that the number of leaves and average height per plant improved with the addition of SMC to soil. As we hypothesized, plants grown in 30% SMC produced the highest average number of leaves 8 while no SMC had the lowest 3. Roma tomato plants grown in 30% SMC growth media had an average of 6 leaves, while there was only an average of 2 leaves in plants grown in either only SMC or only soil. Bean plants grown with 30% SMC had an average of 10 leaves, while there was an average of 3 was recorded in plants grown with 0% SMC. Thus, for all three plants, the hypothesized 30% SMC had the greatest increases in plant height and number of leaves per plant (Table 2).

Survival: We found that plant survival improved with the addition of SMC to soil for both cherry tomato and Roma tomato (Table 1). Adding SMC increased survival rates in plants as compared to only soil. Only 20% of cherry tomato plants survived without SMC. Only 50% of Roma tomato plants survived without SMC.
As we hypothesized, growth media with SMC 30% showed the greatest positive impact on seed germination, plant height, number of leaves and survival rate for all three plants.

DISCUSSION

SMC supports the growth of healthy and lush plants (5). For the soil, it enhances the soil's texture and structure through the positive effects of mulching. This enhancement of the texture can increase plant growth, as the spaces between soil particles contain air that provides oxygen that living cells, like root cells, use to break down sugars and release the energy needed to live and grow. Additionally, SMC helps the growth of microorganisms in the growth media. By increasing microorganism growth, SMC supports access to high levels of important plant nutrients. Moreover, SMC makes the plants less likely to die. For example, plants are susceptible to disease. Therefore, virus-free compost helps harvest healthy plants resistant to infection. SMC helps by reducing the development of weeds, as it blocks the light out from them. Likewise, pests will not harm the plant as this compost is steam-sterilized, so using pesticides is unnecessary. Thus,

Figure 1: Experimental setup for plant growth. Picture of cherry tomato, Roma tomato, and bean plants during the experiment.

Growth Media	Bean		Cherry Tomato		Roma Tomato	
	Germination	Survival Rate	Germination	Survival Rate	Germination	Survival Rate
SMC 0%	75	100	60	20	60	50
SMC 30%	100	100	100	100	100	100
SMC 50%	100	100	100	100	100	60
SMC 70%	100	100	100	40	66	60
SMC 100%	100	100	100	100	100	100

Table 1: Shows the moderate amounts of SMC increase the seed germination rate (%) and the survival rate (%). The average germination rate of 10 seeds measured at the end of 2nd week from each growth media. Average plant survival rate of 5 plants at the end of six weeks from each growth media.

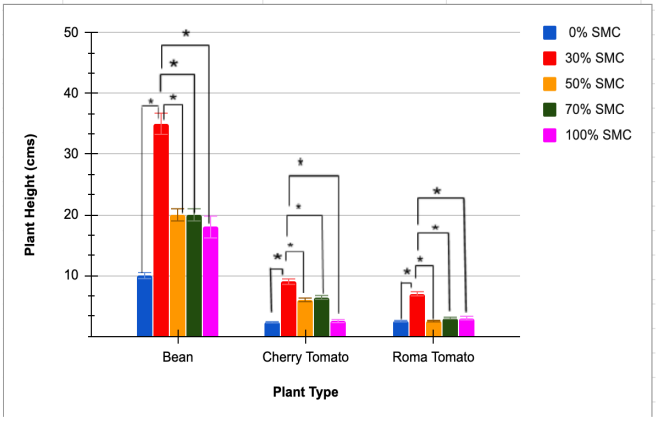

Figure 2: Shows the Moderate amounts of SMC increase plant height. The average height of five plants in centimeters at the end of six weeks from each growth media. Dark blue represents 0% SMC, red represents 30% SMC, orange represents 50% SMC, green represents 70% SMC, and magenta represents 100% SMC. Plants height for growth media of 30% SMC was significantly better than the other growth media. Asterisks (*) show that p<0.05. Error bars set at +/- 5%.

Growth Media	Bean		Cherry Tomato		Roma Tomato	
	Plant Height (cm)	Leaves per plant	Plant Height (cm)	Leaves per plant	Plant Height (cm)	Leaves per plant
SMC 0%	10	3	2.32	3	2.5	2
SMC 30%	35	10	9.00	8	7	6
SMC 50%	20	6	6.00	6	2.5	4
SMC 70%	20	6	6.40	7	3	4
SMC 100%	18	8	2.50	4	3	2

Table 2: Shows the effect of SMC on plant height (cm) and number of leaves (per plant). The average plant height and average number of leaves per plant of five plants in centimeters at the end of six weeks from each growth media.

SMC addition makes growth media more suitable for plant growth (5).

However, there are some drawbacks to using mushroom compost to grow plants (3). Spent Mushroom Compost can have negative effects on the growth of plants. Its high soluble salt levels can kill young germinating seeds and cause damage to sensitive plants. Thus, studies have found reduced growth when mixing increasing amounts of compost into commercial growth media, so we were able to conclude that moderate amounts of SMC would optimize plant growth (5). Plants, specifically seedlings, are sensitive to the high electrical conductivity in compost. SMC can also cause the soil to retain too much water and become waterlogged (6).

For this project, weathered SMC was used, as opposed to fresh SMC, because it is safer for plants. Additionally, SMC undergoes further decomposition for several weeks before farmers utilize it as a soil conditioner. It is better to use weathered SMC to plant crops, due to its lower ammonia gas content, thereby having fewer adverse effects on plants (7). In our experiment, we observed plant growth for 6 weeks. In the future, it would be beneficial to run the experiment over a longer period and measure the size and number of tomatoes/beans produced by each plant and compare that to the relative rate of growth. We were limited by our budget and space to grow plants indoors, so we could not use more than 5 plants per growth media. To gain greater confidence in our results and test for more precise statistical differences between treatments, we could include more replicates for each growth media.

Winter conditions required us to complete this experiment indoors. However, there is a possibility that not all plants obtained the same amount of sunlight through the windows. To overcome this issue, we used a full spectrum light and checked every day to see if plants were getting enough light using a three-way soil meter. Though we tried to mimic the natural environment as closely as possible, we were limited in the amount of change we could make to the temperature and humidity indoors. In future experiments, it would be helpful to have more control over these factors by using either a greenhouse or an outdoor environment.

After analysis, we found that adding SMC has a positive effect on the plant growth of cherry tomato, Roma tomato, and bean plants. Results showed that as stated in our hypothesis, the growth media with 30% of SMC had stronger effects on seed germination, plant height, number of leaves, and survival rate compared to other combinations of growth media. This analysis concludes that a moderate amount of SMC increases the plant growth. Adding the right proportions of SMC will improve soil health, thereby requiring less water.

MATERIALS AND METHODS

To test the effect of SMC, we prepared different growth media with 0% SMC, 30% SMC, 50% SMC, 70% SMC, and 100% SMC. We started the seedling process by following the instructions on the seed packet to ensure optimal conditions for the seeds. Soak seeds in warm water for 2 to 4 hours to soften. Moisten paper towels and spread the seeds evenly and put them in a Ziploc bag for 2 days. Fill planting pots with growth media and put two sprouts into each quad. Regularly irrigate seedling trays with 500 mL deionized water to maintain humidity suitable for plant growing. Using a 3-way soil meter, check every morning and evening to determine if plants are getting enough light.

Sunlight plays an important role in plant growth. Seeds require moderate temperatures of 25°–30°C for germination (8). We used a full spectrum light to maintain the temperature and light illumination. Germinate the seedlings with twelve hours of light for the first two weeks. After this period, increase the time of sunlight to between 14-16 hours daily for the following weeks. The lights allow year-round cultivation. This is important as the plants can get the year-round light that they need.

We measured and recorded the germination growth during the first two weeks. After two weeks we transplanted each plant (5 sprouts per growth media per plant) into 15cm of height biodegradable pots and labeled them using supporting sticks. We collected tap water and let it sit for 24 hours before using it. Seedling trays were regularly irrigated with 500 mL tap water in order to maintain humidity suitable for plant growth. We measured and recorded plant length using a ruler as well as the number of leaves from the 3rd to the 6th week.

Statistical Analysis

To determine whether there were statistically significant differences between different growth media in germination, plant height, number of leaves per plant, and survival rate we applied the t-test using google sheets. 30% SMC data was significant at $p<0.05$ as shown in the Figure 2 with *.

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