The Effect of Spent Coffee Grounds to the Growth of *Solanum lycopersicum* (Tomato)

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Abstract: Six billion tonnes of spent coffee grounds (SCG) are thrown untreated into landfills, leading the spent coffee grounds to leach organic pollutants that may potentially harm bodies of water and emit methane, a greenhouse gas, into the atmosphere. Studies have confirmed that the ratio of carbon and nitrogen (C: N) of SCG is ideal for plant fertilizers. This study focused on determining the effects of SCG on the growth of tomato plants using four parameters: the number of leaves, the average leaf surface area, and the relative growth rate. The study used an experimental research design to study the causal relationship between SCG treatments and plant growth. Tomato seeds were grouped into four and sown on separate pots. The study used three trials, each containing different weights of SCG, namely: 0 g, 5 g, 9 g, and 14 g. The SCG treatments were applied after germination using the side-dressing method. The number of expanded leaves, leaf surface area, and relative growth rate of the tomato plants were observed every five days for 45 days. The researchers found that SCG treatments that exceeded SCG-5 displayed adverse effects on the growth of the tomato. Thus, the relative growth rate and SCG treatments of over 5 g are inversely related to one another. Results show that SCG-5 had the highest positive effect on plant growth in terms of all the parameters. The researchers can then conclude that SCG-5 is an effective alternative fertilizer that improves plant growth.

Key Words: tomato, spent coffee grounds, fertilizer, plant growth, ericaceous plant

1. INTRODUCTION

Solanum lycopersicum, commonly known as tomato, is an economically important and in-demand crop in the Philippines due to its versatility as a nutritious ingredient. This is clearly seen with the increased amount in terms of production in the country (Renna et al., 2018; Manzano & Mizoguchi, 2013). It is classified as an ericaceous plant, which thrives and grows better on soil with low pH, specifically with a 5.5 - 8.0 soil pH range, hence also being in favor of high acid fertilizers (Cubero & Baquiran, 2017).

Tomato has five growth stages, namely the germination stage (25 to 35 d), vegetative period (20 to 25 d), flowering stage (20 to 30 d), early fruiting stage (20 to 30 d), and mature fruiting stage (15 to 20 d). The number of days and success within each stage may vary depending on environmental conditions (Jones, 2013; Garcia et al., 2011). To produce and grow the standard requirements to achieve satisfactory results of plant growth, farmers usually resort to commercial fertilizers. However, the unnecessary overuse of these fertilizers results in increased soil salinity, metal accumulation, water eutrophication, and nitrate accumulation, leading to health hazards and the greenhouse effect (Savci, 2012). Therefore, a need for organic and convenient alternatives is needed to reduce the environmental impact of commercial fertilizers.

Spent coffee grounds (SCG) are the primary solid residual material obtained during the coffee brewing process. When dumped into landfills, they leach high concentrations of organic pollutants into bodies of water, affecting the organisms that live there and emit methane, a greenhouse gas that causes global warming (Cruz et al., 2012; Cervera-Mata et al., 2017; Thenepalli et al., 2017). SCG is known to have a pH level between 6.5 to 6.8 (Coffee Grounds and Composting, n.d.). It has been studied as a potential fertilizing agent throughout recent years due to its nitrogen and potassium content, together with its carbon and nitrogen (C: N) ratios that are ideal for fertilizers (Caetano et al., 2014).

Fertilizers play the role of supplementing the essential nutrients of a plant in order to promote efficient plant growth (Purbatanji et al., 2019). The plant growth of a plant can be assessed in a cost-effective and non-destructive way by measuring its number of expanded leaves, average leaf surface area, and relative growth rate (RGR). The expanded leaves account for the total and average leaf surface area of the plant. Meanwhile, leaf area growth is considered an essential parameter in determining plant productivity as it determines light interception activities. It is also directly correlated to the RGR or the change in mass per day (Wood & Roper, 2000; Paproki et al., 2012 as cited in Pound et al., 2014; Koester et al., 2014).

Thus, this study aims to assess the effects of SCG on the growth of Solanum lycopersicum. Specifically, in terms of the number of expanded leaves, average leaf surface area, and RGR using varying amounts of SCG namely 0 g, 5 g, 9 g, and 14 g.

2. METHODOLOGY

2.1. Planting of Tomato Seeds

The researchers bought tomato seeds from a local nursery. The seeds were first planted on seedling bags, each containing 30 g of topsoil from a local area around Silang, Cavite. The germination phase lasted for 41 d. Once germination is complete, one strong strand from each seedling bag was transplanted into their respective pots each containing 1 L of soil. Given that there were four treatments SCG-0, SCG-5, SCG-9, and SCG-14 with 0 g, 5 g, 9 g, and 14 g respectively, each replicated three times, there were a total of 12 experimental units or pots (see Fig. 1).

Fig 1. Tomato plots

2.2 Application of SCG Treatments

All SCG used was a mixture of Coffea arabica and Coffea canephora beans gathered from Cafe Agapita on the day of application. The SCG treatments were applied through side-dress application during the second week since the plants were transplanted (see Fig. 2). They were furrowed 2 in. deep and at least 2 in. away from the plant in a circle around each plant and covered with soil. Netting was also done by setting up the wooden planks apart from each other and covering them entirely with 0.4 mm x 0.7 mm small mesh nets. The researchers introduced the SCG to the plants three times in equal amounts in a fifteen-day interval.

Fig 2. Side-dress application of SCG Treatments

The plants were examined every five days for 45 days for the changes in the number of the expanded leaves, leaf surface area, and relative growth rate (RGR). All leaves on the plant, no matter how small, were counted for the number of expanded leaves. The researchers used ImageJ software (Fig. 3) to measure the leaf surface area of all leaves on each plant. This data was then used to determine whether there is an increase or decrease in the RGR of the tomato plants.

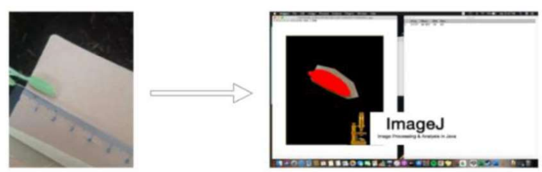

Fig 3. Leaf area measurement sample using ImageJ

3. RESULTS AND DISCUSSION

3.1 Number of Expanded Leaves

Fig. 4 shows the data on the number of expanded leaves collected over 45 days. The plants in SCG-9 have the highest number of leaves among the pots on the initial collection of data. However, an increase in the number of leaves on plants was seen on SCG-5 plants upon the second SCG application. Thus, SCG-5 garnered the highest number of leaves with 20 leaves leaving SCG-0 and SCG-9 with the second and third highest number of leaves and SCG-14 with the least number of leaves, 19 and 16 respectively.

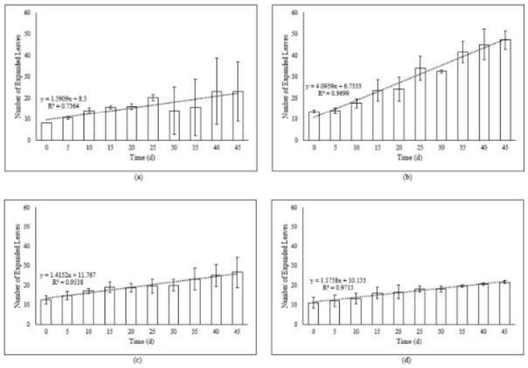

Fig 4. Average number of expanded leaves for (a) SCG-0, (b) SCG-5, (c) SCG-9, and (d) SCG-14.

After 15 d, a continuous increase was displayed by the plants in SCG-5. On the other hand, a slow rise in the growth of leaves in SCG-9 resulted in fewer leaves than SCG-0. SCG-5, followed by SCG-0, SCG-9, and SCG-14, displayed a decreasing trend in its number of expanded leaves which continued until the end of the data collection period.

A higher number of expanded leaves would, in turn, mean that SCG-5 observed the most considerable amount of growth (Wood & Roper, 2000). However, it is also worth noting that the control group, SCG-0, has the second-highest number of expanded leaves. This leaves a negative implication that greater amounts of SCG affect the emergence of leaves on the tomato plant.

The results imply that low concentrations of SCG applied are more effective in plant growth. This is evident by the data in the number of expanded leaves as SCG-5 showed the most significant increase in the number of expanded leaves.

3.2 Average Leaf Surface Area

Fig. 5 shows the average leaf surface area obtained on the 45th day of tomato plants grown in four varying SCG weights.

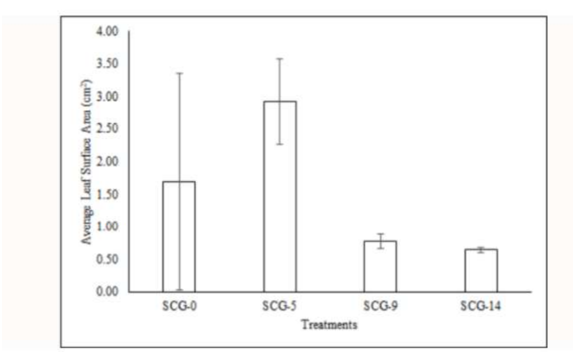

Fig 5. Average leaf surface area in respect to the amount of SCG at t = 45 d.

Upon the last day of data collection, SCG-5 had the highest average leaf area with a value of 2.92 cm2. SCG-0 came second with an average leaf area of 1.69 cm2, followed by SCG-9 with 0.77 cm2, and last was SCG-14 with 0.64 cm2.

The changes in leaf surface area may be due to varying environmental conditions such as climate, topography, and soils (Trimble, 2019). However, leaf surface area changes are more tightly related to soil nutrient status, specifically C: N ratios or N mineralization, than climate. Considering that the C: N ratios in SCG are ideal for fertilizers, the SCG is most likely to be the cause of the changes in leaf surface area (Gong & Gao, 2019; Ordonez et al., 2009; Caetano et al., 2014).

The plausible cause for affecting the soil nutrients status is overfertilization which may be rooted in the excessive amounts of fertilizer added at one time. The salinity of excessive SCG could have promoted the reduction of photosynthesis and an increase in leaf dehydration (Kozlowski et al., 1997; Ciesielczuk et al., 2018). Moreover, SCG may have caused high N-buildup in the soil that led to excessive vegetative growth, yet turning younger leaves into smaller sizes, delaying the growth of tomato plants (Sainju, Dris, & Singh, 2003). Thus, greater amounts of SCG applied resulted in lower leaf surface area values.

3.3 Relative Growth Rate

Fig. 6 shows the total leaf surface area of tomato plants treated with varying amounts of SCG throughout 45 d.

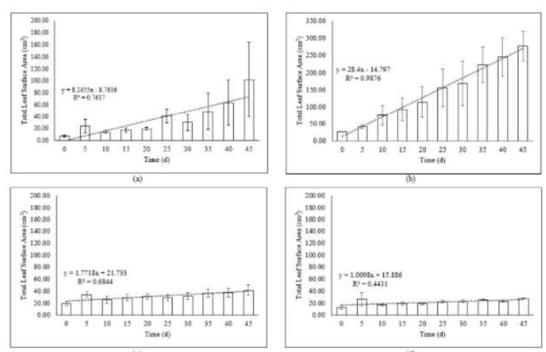

Fig 6. Total leaf surface area of (a) SCG-0, (b) SCG-5, (c) SCG-9, and (d) SCG-14.

Fig 6. Total leaf surface area of (a) SCG-0, (b) SCG-5, (c) SCG-9, and (d) SCG-14.

Table 1 summarizes the RGR of the tomato plants. The slope of the trendline for the total leaf surface area (as shown in Fig. 6) served as the RGR as it measures the change in total surface area, accounting for the mass of the plant, over the change in time.

Table 1. Relative growth rates of all treatments.

Treatment	RGR (cm^2/d)
SCG-0	8.2455
SCG-5	28.4
SCG-9	1.7718
SCG-14	1.0098

SCG-5 yielded the highest RGR among all the other SCG treatments with 28.4 cm2/d, followed by SCG-0, SCG-9, and SCG-14 with values 8.2455 cm2/d, 1.7718 cm2/d, and 1.0098 cm2/d, respectively.

From the data, the greater amount of SCG applied led to low RGR values. Factors that cause it may be the minerals and nutrients accumulated in the tomato plants as the incorporation of SCG increases the nitrogen, potassium, and phosphorus contents (Chrysargyris et al., 2020). As aforementioned in Section 3.2 of this paper, excess nutrient content is a sign of overfertilization resulting in the decline of the photosynthetic ability of the plant. Thus, creating smaller leaves, implying lower value for the mass of the plants, leading to the stunted growth rate of tomato plants. Moreover, overfertilization in potted plants also leads to very low or no plant growth at all (Woorman, 2011).

4. CONCLUSIONS

Results for all parameters showed that SCG-5 had the best plant growth results compared to SCG-9 and SCG-14, which displayed signs of overfertilization. It also surpassed the growth of the tomato plant without any treatments of SCG, making SCG-5 a viable fertilizer for tomato plants. To further support this finding, the most appropriate amount of SCG to be applied from 0 to 8 g can be identified in order to determine the highest amount for maximum efficiency properly. Other stages and parameters of plant growth that were not assessed in this study due to its limitations can also be evaluated. Moreover, future researchers may explore different methods of SCG or fertilizer application as well.

5. ACKNOWLEDGMENTS

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