Hong Kong Student Science Project Competition 2023

Template of Extended Abstract (Investigation)
(Word Limit: 1,600 words, Pages: 3 pages only)

Team Number: JBBC123

Project Title: Amending desert soils with inedible food waste

Project Type: Investigation

***To our best knowledge, there are similar works in the field*; (if there are,) related research links are as below:**

http://archive.sciendo.com/INTAG/intag.2015.29.issue-1/intag-2015-0008/intag-2015-0008.pdf

The enhancement our project made / the difference with related research are:

We tested and increased the bagasse to soil ratio and also added crushed and dried banana peels and eggshells in three other samples, which also includes 2 compositions of desert sand, not only sandy soil.

I. Background

In our current era, where many problems such as global warming and Covid-19 taking centre stage, we believe that we tend to overlook the ongoing issue of desertification. Over the years, thousands of people have lost their villages, crops, and even their lives to the rapid spread of desertification._Desertification is a type of land degradation that causes the depletion of natural resources by natural or man-made processes. Usually occurring near arid drylands, countries such as China, India, Iran, Mongolia, and Pakistan. While this problem is nothing new, the sudden surge in the rate of desertification has many alarmed. According to the UNEP, the rate of desertification is at an all-time high, up to 30-35 times the historical rate.

Another problem is inedible food waste. Of all Hong Kong's rubbish, about 3,255 tonnes (30%) were food waste, reported being the largest category of solid waste. Considering that Hong Kong's population is roughly less than 0.1% of the world's population, this number becomes incredibly concerning. After researching, we found a common type of food waste, bagasse (a leftover pulpy fibrous material after sugarcane crushing) is one of the contributing factors to large amounts of food waste. Although some are already reused for food packaging, replacing styrofoam due to its paperlike texture and its biodegradability; some bagasse is used as fuel, however burning causes degradation of air quality. Due to its great properties such as water retention, presence of organic matter, and nutrients including potassium, we believe it would work great as a fertilizer. By repurposing bagasse, we can reduce both tackling desertification and the harmful toxins released, and therefore, reduce pollution.

II. Objectives

To find if the addition of bagasse (BG), banana peels (BP) and egg shells (ES) is able to amend infertile desert soil and create optimum growth conditions for the cherry tomato plant.

III. Hypothesis

We believe that plants in sandy soil with the addition of fertilizer with 15%BG, 3%BP, and 3%ES would achieve the highest output in growth. This is because previous research (El-Halim, 2015) has demonstrated that the inclusion of BG into sandy soil shows significant growth and a positive change in the nutritional value of the sandy soil, thus we believe that adding in other types of food waste such as BP and ES will create an increase in nutritional content, balance out high acidity and increase the water holding capacity. This allows the soil to be more favorable for cherry tomato plants. This hypothesis can be tested through the assessment of plant growth by measuring calculating the Average growth rate, final length of the plant and leaves. Moreover, additional experiments such as the percolation and pH test can help us first deduce the percentage of BG, ES and BP.

IV. Methodology

Materials used:
Washed eggshells (EG), Banana peels (BP), Bagasse (BS), Garden Soil, Sandy Soil, immature sand (58.875% SiO, 16.5% feldspar, 13.125% muscovite, 11.5% basalt), mature sand (98.5% SiO, 1% feldspar, 8.36% basalt), Tomato Seeds.

We chose to the following set-ups:

Soil type	% of BG	% of BP	% of ES
Immature sand with fertilizer	20	6	3
Mature sand with fertilizer	20	6	3
Sandy soil with fertilizer	15	3	3
Sandy soil with bagasse	10	0	0
Garden Soil (positive control)	0	0	0
Sandy Soil (negative control)	0	0	0
Mature sand (negative control)	0	0	0
Immature sand (negative control)	0	0	0

We used garden soil as a positive control as it was tested to have the best WHC, and its pH is also within the range of our optimum pH. By comparing our sample setups with garden soil, we are trying to prove that the addition of BG, BP and ES can cause plants to grow as well as they would in garden soil.

We used sandy soil, mature and immature sand as the negative control, mimicking the original conditions of desert soil as it prove the addition of BG, BP and ES can make desert soils more suitable for plant growth through comparison.

Overview of experimental procedures:
Percolation Test
pH Test
Preparation of cherry tomato seeds
Growing cherry tomato and measuring plant height
Harvesting plant and measuring weight

We decided to measure the length of the cherry tomato plant from its root to the tip of its leaf. This is the most common form of plant growth measurement and indication, because a larger length generally shows that the plant has gone through an irreversible change in its size (Rajesh Pandey, 2017). A greater leaf size also indicates that the plant can absorb more sunlight. At the end of the experiment, we also calculated the mean average growth rate (AGR) of the plants in each set-up, which is the rate of increase in dry matter, using the formula as follows:

$$\text{AGR} = \frac{W_2 - W_1}{t_2 - t_1}$$

Where W_1 is the initial mean dry weight of the plant at time t_1 when we first planted them, and W_2 is the final mean dry weight of the plant at time t_2 when we harvested them. This indicates the rate of increase in the dry mass of the leaf, which is accurate in measuring plant growth. (Rajesh Pandey, 2017). Moreover, by using the mean dry weight, we can factor in the plants that did grow as well as those that didn't, thus better representing the value.

V. Results

Soil type	Final plant length/cm					Mean:	Standard deviation
Sandy soil with 15%BG, 3%BP, 3%ES	8.5	9.1	7.9	8.1	0	6.7	3.8
Immature sand with 20%BG, 6%BP, 3%ES	7	4.5	4.2	3.6		4.8	1.5
Mature sand with 20%BG, 6%BP, 3%ES	7.8	7.1	8.3	0	0	4.6	4.3
Garden soil	12.5	7.9	0	0	0	4.1	5.8
Sandy soil with 10%BG	5.1	3.9	0	0	0	1.8	2.5
Mature sand	0	0	0	0	0	0	0
Immatue	0	0	0	0	0	0	0
Sandy soil	0	0	0	0	0	0	0

As expected, the sandy soil with 15%BG, 3%BP, 3%ES has the highest mean length of the plant - a significant improvement from the sandy soil with only 10%BG. Still, the immature sand with 20%BG, 6%BP, 3%EG has the second-highest mean plant length and the lowest standard deviation, indicating that this growing environment is the most stable. In comparison to the negative controls which did not grow at all, a large proportion of each set-up shows that the inclusion of BG and other inedible food waste can amend infertile soil. Although garden soil has the highest individual plant length, it has the lowest mean plant length out of the plants that showed results as only 2 out of 5 set-ups sprouted, resulting in the large standard deviation which reveals that the addition of BG in the desert soils create a more stable growing environment than garden soil.

Soil type	Leaf length/cm					Mean leaf length/cm	Standard deviation
Sandy soil with 15%BG, 3%BP, 3%ES	3	2.2	1	1.6	0	1.6	1.1
Immature sand with 20%BG, 6%BP, 3%ES	2.5	1.6	1.6	2	0	1.5	0.9
Mature sand with 20%BG, 6%BP, 3%ES	1	2.5	0.4	0	0	0.8	1.0
Sandy soil with 10%BG	2.3	0	0	0	0	0.5	1.0
Garden soil	2.4	0	0	0	0	0.5	1.1
Mature sand	0	0	0	0	0	0	0
Immature sand	0	0	0	0	0	0	0
Sandy soil	0	0	0	0	0	0	0

The mean leaf length of immature sand with 20%BG 6%BP, 3%ES samples and sandy soil with 15%BG 3%BP, 3%ES samples are respectively 1.5 and 1.6 cm, ranking the largest length out of the five setups. To add on, the set-ups of mature sand, immature sand and sandy soil added with BG, BP and ES, had a larger mean leaf length and more plants that developed leaves than both the setup with only garden soil and sandy soil with 10%BG. Therefore, the BG, BP and ES acting together is more beneficial to the plant than solely BG and shows more development than that of plants in garden soil. Moreover, the set-ups with bagasse show that leaves can be developed, unlike the negative controls which did not sprout at all. Thus, this once again proves that the addition of BG has made the soil more suitable for plant growth.

Soil type	Final dry weight/mg					Mean dry weight/mg	Mean AGR/mg/day	Standard deviation
Immature sand with 20%BG, 6%BP, 3%ES	8	7	7	4	0	5.2	0.152	3.3
Mature sand with 20%BG, 6%BP, 3%ES	9	8	1	0	0	3.6	0.088	4.5
Sandy soil with 15%BG, 3%BP, 3%ES	6	4	4	4	0	3.6	0.088	2.2
Sandy soil with 10%BG	9	4	0	0	0	2.6	0.048	4.0
Garden soil	1	1	0	0	0	0.4	-0.04	0.5
Immature sand	0	0	0	0	0	0	0	0
Mature sand	0	0	0	0	0	0	0	0
Sandy soil	0	0	0	0	0	0	0	0

From the results, we can see that the immature sand with 20%BG, 6%BP, 3%ES has the highest mean AGR and that 4 out of 5 set-ups all showed relatively consistent results, this shows that the immature sand has the fastest growth rate. On the other hand, sandy soil with 15%BG, 3%BP, 3%ES had a 183% (3 s.f.) quicker growth rate compared to the set-up with only sandy soil and 10%BG Thus, this emphasizes that the addition of BP and ES makes the soil even more suitable for plant growth than solely BG. Overall, compared to the negative controls which showed no growth whatsoever, the growth of the plants in the mediums with BG once again shows that the once infertile soils were able to be effectively amended with BG.

VI. If your team will compete the Sustainable Development Award, please indicate the specific sustainable development goal the project is related to, and provide justification for competing for this award. *(Word limit: 300 words)*

The project is related to the goals of Zero Hunger and Life on Land. We aim to achieve food security in less economically developed countries as more crops can be grown on desert soil and can also be sustained and watered through manual labour or a drip irrigation system etc. This allows the less economically developed countries to have a more sustainable agriculture system and more cropland to grow food and provide a way of also earning income and a nearby mass source of food production. Moreover, our project is also related to the Life on Land goal because this method can also be a way to combat desertification as it turns useless desert soil into arable land. The addition of organic matter from the fertiliser will also enrich the soil with nutrients.

VII. Conclusion

After compiling the results and comparisons from the data above, we can conclude that the addition of BG successfully amends infertile desert soil as the set-ups with BG showed larger plant and leaf lengths and a higher AGR than the desert soils without anything added to them, meeting the objectives. The set-ups with BG also showed larger plant and leaf lengths than the garden soil, indicating that our composition is better suited for cherry tomatoes than garden soil, however, growth of the plants and the data for garden soil may have been hindered by external factors. Additionally, the sandy soil with 15%BG, 3%ES and 3%BP showed a higher AGR, larger plant and leaf lengths than sandy soil with only 10%BG, thus the addition of BG, BP and ES further improves growing conditions for plant growth. In the future, other crops can also be grown such as soybean or onion as the results may vary among different plants. To achieve this, the ratio of the fertilizer can be adjusted in the future to match the preferences of the plant. This would also allow more analysis for better understanding as we can observe if the growth rate has similar trends. Furthermore, to sustain the crops grown in the amended desert soil, the plants could be watered through manual labor or a drip irrigation system etc.

☐ **Our project is developed based on previous project and the enhancement is below:**

We tested and increased the bagasse to soil ratio and also added crushed and dried banana peels and eggshells in three samples, which also includes 2 compositions of desert sand, not only sandy soil.