Evaluating the quality of the compost produced at Al Safir Compost Production Unit and Learning Center on the seed germination and tree growth

Protocols developed by

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Protocol 1: The Impact of Two Tree Composts on Orchard's Performance (Apple trees)

Introduction:

Apple cultivation stands at the core of horticultural practices worldwide, as the apple's global demand continues to thrive. Orchards are not just the apple trees themselves but the harmonious synergy between trees and the soil they grow in. To foster robust growth, high yields, and optimal fruit quality, orchard management demands a careful consideration of soil health and fertility. An increasingly common approach to enriching soil vitality involves the application of organic amendments such as compost.

This research embarks on a comprehensive examination of the influence of two distinct types of compost, referred to as "Type A" and "Type B," on the performance of a young apple orchard. With a burgeoning apple industry, the significance of prudent orchard management practices cannot be overstated. Compost quality, and the inherent variability of different compost materials, can profoundly affect orchard performance, particularly when applied to young trees, which are at a crucial stage of development.

Compost is a valuable organic material that can be used to improve soil health and plant growth. It is made up of decomposed organic matter, such as food scraps, yard waste, and manure. The application of compost to orchards is currently uncommon in commercial operations but could potentially replace synthetic fertilizers and improve long-term orchard sustainability.

Compost can be used to improve the performance of young apple trees in a number of ways. It can help to improve soil health, which can make trees more resistant to pests and diseases. Compost can also provide trees with the nutrients they need to grow and produce fruit.

A number of studies have shown that compost can improve the performance of young apple trees (Khorram et al, 2019; Brown and Tworkoski, 2004). The purpose of this study was to monitor how applications of 2 different types of compost to replace synthetic fertilizer would change soil quality, and tree performance. We will compare the performance of trees that are fertilized with two different types of compost to the performance of trees that are not fertilized with compost. Application (incorporation or mulching) of compost into soil can significantly alter soil physical properties, nutrient dynamics, and vegetation establishment.

We hypothesize that the two different composts will have a positive effect on young apple orchard performance. We believe that compost will help to improve soil health, which will make the trees more resistant to pests and diseases and will provide the trees with the nutrients they need to grow and produce fruit. With compost incorporation at planting, you can also expect your trees to grow taller and have thicker trunks. Australian research has demonstrated this effect during the first 18 months in new apple, almond and citrus orchards when compost is incorporated at planting. Young trees which are taller and stronger have a significant advantage.

The results of this study will provide valuable information about the use of compost to improve the performance of young apple orchards. This information can be used by apple growers to improve the productivity and profitability of their orchards.

Disclaimer:

The outcomes of this study may be influenced by various external factors such as variations in pesticide application, tillage practices, mulching, and tree recovery from stress events. While every effort will be made to standardize these variables across all plots, the results should be interpreted with caution, considering the potential for these factors to impact the overall performance of the young apple orchard.

Experimental site:

A --- square meter (--- m2) field site at Al Safir Orchard in Al Ghaziyeh Area at 5.3 km from Saida (10 minutes by car), and 49 km from the Lebanese capital, at an altitude of about 50m, facing the sea, characterized by a Mediterranean climate, characterized by hot, dry summers and mild, wet winter, with an annual amount of rainfall of 778 mm, and average annual temperature of 25℃, was selected for field experimentation. The experimental site was planted with apple trees in 2011, that died due to water shortage. So, the orchard was replanted in 2018 with two different apple trees variety, Coastal and Gana.

Application:

Different applications were experimented in many orchards of different cultivation, climate, soils, etc. In fact, all these applications fall under two main methods of compost application to tree in orchard:

1- Mulching: This is the most common way to apply compost to trees. To mulch, simply spread a layer of compost around the base of the tree, extending out to the drip line. The compost layer should be 2.5-7.5 cm thick. A variety of organic materials have been used as mulch to suppress weeds and improve soil fertility (Cogliastro et al., 1993; Pinamonti, 1998; Arthur and Wang, 1999).

2- Incorporating into the soil: This method is less common, but it can be beneficial for young trees or trees that are struggling due to its rapid. To incorporate compost into the soil, dig a shallow trench around the base of the tree, extending out to the drip line. The trench should be about 6 inches deep. Fill the trench with compost and then backfill with soil.

In agriculture, there are two common methods for applying composts to soil: incorporation and mulching (Cogger et al., 2008). Compost incorporation into the top few centimetres increases accessibility for soil microbes and also contact with the plant roots, and thus have a greater effect on soil C, N, and bulk density than surface application (mulching) (Cogger et al., 2008). Mulching is common in horticulture and agriculture in dry climates because it minimizes water loss by evaporation (Agassi et al., 1998; Gonzalez and Cooperband, 2002). Compared to incorporation, the effect of mulching on the underlying soil can be expected to be smaller as it is limited to soluble compounds leaching from the mulch layer into the soil and due to the lower accessibility to soil organisms (Gonzalez and Cooperband, 2002). Compost with a coarse texture is considered the best for mulching because it allows water and air to move through to the soil underneath. It also decomposes slowly and is therefore

long-lasting. Fine textured material can also be used as mulch but if applied too thickly it can trap water and prevent it from reaching the soil; this only generally occurs if the compost is applied in a layer of more than 5cm thickness (Agassi et al., 1998; Paulin and O'Malley, 2008).

Using compost extract can be a good choice also especially when the quantity of compost is not sufficient to cover all the orchard.

In our case, we are going to use the incorporation method and for mulching we are going to add wood chips

1- Wooden mulching + compost extract

By combining wooden mulch with compost extract in this manner, you create a favorable environment for the establishment and growth of the young apple orchard. This integrated approach supports soil health, water conservation, and overall orchard vitality.

- Ensure the orchard is properly prepared by clearing debris, weeds, and other vegetation. Make sure the soil is adequately moist but not waterlogged.
- Choose a high-quality wooden mulch. Ideally, the mulch should be well-aged to prevent nitrogen competition with the young apple trees (Chalker-Scott, 2007). The mulch should also be free of pests and diseases.
- Prepare compost extract by mixing compost with water. Allow the compost extract to steep for a sufficient period to extract beneficial microorganisms and nutrients.
- Before applying mulch, evenly distribute the compost extract around the base of each young apple tree. This helps introduce beneficial microorganisms to the root zone.
- Apply a layer of wooden mulch around each olive tree. The mulch layer should be approximately 2 to 4 inches (5 to 10 cm) deep.
- Leave a small gap around the tree trunk to prevent direct contact with the mulch. Extend the mulch layer to cover the entire root zone, reaching the drip line of the apple trees. This helps conserve moisture, regulate soil temperature, and suppress weed growth in the entire root zone.
- Periodically replenish the mulch layer as it decomposes. This ensures continued benefits for the apple trees.

2- Incorporation

The frequency of compost incorporation into an apple orchard depends on various factors, including the soil conditions, compost quality, and the specific needs of the olive trees. Many apple orchards benefit from an annual compost application. This is typically done before the growing season to provide nutrients and improve soil structure.

- Ensure that the compost is well-processed and free from contaminants.
- Evaluate the soil structure and moisture content to determine the appropriate time for incorporation. Soil should be moist but not waterlogged.
- Ensure the orchard is properly prepared by clearing debris, weeds, and other vegetation.

- The recommended application rate can vary, but a common guideline is to apply compost at a rate of 1 to 3 inches (2.5 to 7.5 cm) over the orchard surface.
- Young apple trees may benefit from a lighter application of compost initially. As the trees mature, adjustments can be made to the quantity based on their increasing nutrient needs.
- To incorporate compost into an apple orchard, begin by ensuring the compost is well-processed and free from contaminants.
- Spread the compost evenly across the orchard using a spreader or by hand, considering the recommended application rate for your specific soil and crop requirements.
- Use the chosen equipment to mix the compost into the soil. This can be a one-pass operation or may require multiple passes, depending on the equipment and the amount of compost being incorporated.

Protocol

Title: Comparative Study on the Effects of Two Composts on Young Apple Orchard Performance

Objective: To compare the impact of two distinct types of compost (Type A and Type B) on the growth, fruit yield, and soil quality of a young apple orchard.

Duration: a multi-year study is recommended to capture changes in tree growth, fruit production, and soil health. A minimum duration of 2 years is recommended for a short-term experiment. However, for a more thorough and in-depth analysis, a long-term experiment extending over 5 years or more is advisable. Long-term studies provide valuable insights into the sustainability and lasting effects of compost application on the orchard's performance. They help account for fluctuations in tree health, fruit yield, and soil quality over extended periods.

Treatments:

- Treatment 1: Compost A- mulch
- Treatment 2: Compost A- incorporation
- Treatment 3: Compost B- mulch
- Treatment 4: Compost B- incorporation
- Treatment 5: Control

Design:

- Randomized complete block design (RCBD)

Blocks:

- 4 blocks, or 3 blocks

However, using 3 blocks will reduce the power of the experiment and make it less likely to detect significant differences between the treatments. In general, more blocks will lead to a more powerful experiment and a greater chance of detecting significant differences between treatments. However, more blocks also mean more work and more resources.

Variables:

- Independent variable: Types of Tree compost produced in Al Safir Orchard + Soil
- Dependent variables:
  Tree growth, fruit yield, weed growth, pest and disease incidence
  In addition to these parameters, you may also want to measure other plant growth indicators, such as stem diameter, number of leaves, and number of branches.

Monitor and record relevant environmental factors like temperature, precipitation, and weather conditions, as these variables can influence tree growth and fruit yield.

Materials:

1- Type A Compost
2- Type B Compost
3- 60 Young apple trees (of similar age and variety)
4- Soil testing kits (optional)
5- Measuring tape
6- Data recording sheets (excel sheet)
7- Gardening tools
8- Markers (waterproof)
9- Weighing scale

Experimental setup:

1- **Preparation of Compost**:
   - Obtain two different types of compost (A, and B).
   - Ensure that each type of compost is thoroughly decomposed and ready for use.
   - Calculate the quantity of needed compost after specifying the needed quantity for each tree.
2- **Select three areas** within your young apple orchard for experimentation, ensuring the three areas have similar soil types, tree varieties, and initial growth conditions.
3- **Randomly assign** the two Type A compost treatment to one area and the two Type B compost treatment to the other. Designate a third area as a control (no compost application) for reference in each block. Each block is divided into 5 subplots each containing 4 tees assigned to one of the five treatments.
4- **Mark** each tree clearly so that you can easily identify them and track their performance over time.
5- **Measure and record** baseline data for tree growth, fruit yield, and soil conditions in all areas before the experiment begins if possible.
6- Apply Type A compost to the designated area following the two predetermined application rate and schedule. Apply Type B compost to the other designated area using the same guidelines. Avoid compost application in the control area.

Apply the composts at the same rate. The amount of compost that you apply will also affect tree performance. It is important to apply the two composts at the same rate, so that you can directly compare their effects.

7- **Collect data** on the following parameters:

- Tree growth:
  - Tree height: Measure the height of each tree at specific intervals.
  - Collar diameter: Measure the diameter of the tree 30 cm above the soil level using a caliper or any other tool if not found (thread and meter maybe).
- Fruit yield:
  - Number of apples harvested per tree.
  - Weight or size of the harvested apples.
  - Fruit quality factors such as flavor, appearance, and shelf life.
- Soil conditions: IF POSSIBLE
- Weed Growth:
  While not always a primary focus, you may choose to measure weed growth as a dependent variable, as compost can also impact weed pressure in the orchard.
- Disease and Pest Incidence:
  Observe and record the incidence of diseases and pests affecting the apple trees as dependent variables. Healthy trees are less susceptible to pests and diseases, so changes in these variables can reflect the impact of compost on tree health.
- Environmental Factors:
- Monitor and record relevant environmental factors like temperature, precipitation, and weather conditions, as these variables can influence tree growth and fruit yield to explain the cause of any aforementioned parameters.

8- **Maintain** detailed records of compost application dates, rates, and any observations or issues in the orchard.

9- **Analysis:** After several years of data collection, analyze the results to compare the effects of Type A and Type B compost on young apple orchard performance. Use statistical analysis tools to assess differences between the compost types and the control area.

10- **Presentation of Results:** Present the data in tables, graphs, or charts for better visualization. Include a discussion of the implications of the findings.

11- **Conclusion:** Draw conclusions based on data analysis regarding the effects of different compost types on young apple trees. Discuss any practical implications and potential recommendations for using specific compost types in gardening or agriculture.

12- **Reporting:** Document findings in a research report or paper, including methodology, results, and discussion.

Remember to maintain consistency in all aspects of the experiment except for the type of compost used and the method of application to ensure that any observed differences are attributed to the compost type.

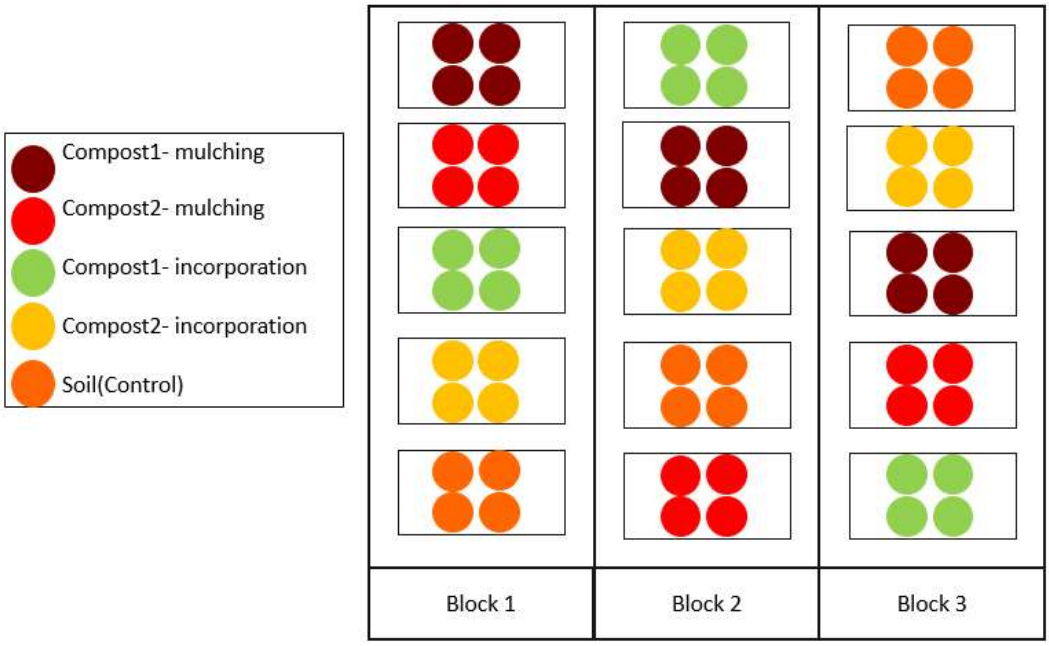
Experimental Design

- A common experimental design for this type of experiment is a randomized complete block design (RCBD). In an RCBD, the treatments are randomized within each block. This helps to reduce the effects of any variation between blocks, such as sunlight and slope for example.

- Experimental design: Randomized complete block design (RCBD)

- Treatments:
  - Treatment 1: Compost A- mulch
  - Treatment 2: Compost A- incorporation
  - Treatment 3: Compost B- mulch
  - Treatment 4: Compost B- incorporation
  - Treatment 5: Control

- Replications: 3



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Protocol 2: The Impact of Two Tree Composts on Orchard's Performance (Olive trees)

Introduction:

The olive (*Olea europaea L.)* holds a prominent position in Lebanese agriculture (Chehade et al., 2012), covering approximately 31.6% of the country's fruit tree cultivation area (FAO, 2020). With a rich history dating back to ancient times, Lebanon boasts the cultivation of very old olive trees, reflecting the enduring tradition of olive growing (Yazbeck et al., 2018; Chalak et al., 2015).

Olive groves in Lebanon can be found at various altitudes, ranging from coastal plains to mountainous regions. The country's diverse climate, influenced by the Mediterranean and mountainous topography, provides favorable conditions for olive tree cultivation.

Despite the enduring tradition of olive cultivation, challenges arise due to substantial erosion and off-site contamination in the dry Mediterranean region, negatively impacting yields. Effective soil management and water preservation methods are imperative to mitigate these challenges, preventing detrimental effects.

Agricultural practices, based on periodical organic amendment inputs are strongly recommended for poor soils, especially those of Mediterranean agroecosystems. Composting was considered as an effective biological, economical and sustainable process to reuse the organic matter wastes (Muscolo et al., 2018; Doña-Grimaldi et al., 2019). Indeed, the composting 2 process stabilizes the organic wastes by their conversion into humic substances and inactivates pathogen flora, allowing compost use for soil amendment (Zhang and Sun, 2015). Composts prepared from different agroindustrial by-products are commonly used as organic fertilizers (Ibrahimi and Gaddas, 2015). The compost application can potentially affect the soil organic matter levels and nutrient status. As a result, compost use has received great attention from agriculturists and environmentalists because of direct and indirect effects on the soil properties improvement, as well as on the plants growth and yields (Toumpeli et al., 2013). Olive grove soils are typically Mediterranean, characterized by low organic matter content, by the semiarid climate in which they develop, and degradation by human activities

(Nieto et al., 2010). Olive grove soils therefore typically show less than 1% in organic carbon especially in arid regions (Chehab et al., 2019). In this context, increasing soil organic matter becomes imperative. Indeed, when applied in field trials as an organic additive, compost can improve the soil physicochemical properties which affect positively the plant yield (Boutchich et al., 2018).

Experimental site:

A --- square meter (--- m2) field site at at Al Safir Orcahrd in Al Ghaziyeh Area at 5.3 km from Saida (10 minutes by car), and 49 km from the Lebanese capital, at an altitude of about 50m, facing the sea, characterized by a Mediterranean climate, characterized by hot, dry summers and mild, wet winter, with an annual amount of rainfall of 778 mm, and average annual temperature of 25°C, was selected for field experimentation. The experimental site is planned to be planted with local olive varieties.

Application:

Different applications were experimented in many orchard of different cultivation, climate, soils, … In fact, all these applications fall under two main methods of compost application to tree in orchard:

1- Mulching: This is the most common way to apply compost to trees. To mulch, simply spread a layer of compost around the base of the tree, extending out to the drip line. The compost layer should be 2.5-7.5 cm thick. A variety of organic materials have been used as mulch to suppress weeds and improve soil fertility (Cogliastro et al., 1993; Pinamonti, 1998; Arthur and Wang, 1999; Lu et al., 1999).
2- Incorporating into the soil: This method is less common, but it can be beneficial for young trees or trees that are struggling due to its rapid. To incorporate compost into the soil, dig a shallow trench around the base of the tree, extending out to the drip line. The trench should be about 6 inches deep. Fill the trench with compost and then backfill with soil.

In agriculture, there are two common methods for applying composts to soil: incorporation and mulching (Bastida et al., 2010; Cogger et al., 2008). Compost incorporation into the top few centimetres increases accessibility for soil microbes and also contact with the plant roots, and thus have a greater effect on soil C, N, and bulk density than surface application (mulching)(Cogger et al., 2008). Mulching is a common in horticulture and agriculture in dry climates because it minimizes water loss by evaporation (Agassi et al., 1998; Agassi et al., 2004; Gonzalez and Cooperband, 2002; Tu et al., 2006). Compared to incorporation, the effect of mulching on the underlying soil can be expected to be smaller as it is limited to soluble compounds leaching from the mulch layer into the soil and due to the lower accessibility to soil organisms (Gonzalez and Cooperband, 2002). Compost with a coarse texture is considered the best for mulching because it allows water and air to move through to the soil underneath. It also decomposes slowly and is therefore long-lasting. Fine textured material can also be used as mulch but if applied too thickly it can trap water and prevent it from reaching the soil; this only generally occurs if the compost is applied in a layer of more than 5cm thickness (Agassi et al., 1998; Paulin and O'Malley, 2008).

Using compost extract can be a good choice also especially when the quantity of compost is not sufficient to cover all the orchard. In our case, we are going to use the incorporation method and for mulching we are going to add wood chips.

1- **Mulching**

To apply compost mulching in an olive orchard, follow these steps:

Frequency:

In most cases, it's common to apply mulch annually or every other year. This helps maintain a consistent layer of mulch and provides ongoing benefits to your orchard.

Rate:

Apply mulch at a depth of about 2 to 4 inches (5 to 10 cm). This depth provides adequate coverage to conserve moisture, suppress weeds, and regulate soil temperature. Avoid applying mulch directly against the tree trunk to prevent issues like rot).

Timing:

The best time to apply compost is in the early spring or late fall, when the trees are dormant and not actively growing. Avoid applying compost during the growing season to prevent potential damage to the roots.

Prepare the soil:

Before applying compost, it is important to prepare the soil. This can be done by removing weeds and debris, and by loosening the soil with a shovel or rototiller.

Apply the compost:

Carefully spread the compost around the base of each tree in a donut-shaped pattern. Make sure the compost is evenly distributed within the designated area. Keep the compost away from the tree trunk to prevent rot.

Water Thoroughly:

After applying the compost, water the area thoroughly. This helps the compost nutrients infiltrate the root zone and promotes settling of the compost.

2- Incorporation

To apply compost incorporation in an olive orchard, follow these steps:

Frequency:

In most cases, it's common to apply mulch annually or every other year. This helps maintain a consistent layer of mulch and provides ongoing benefits to your orchard.

Rate:

Apply mulch at a depth of about 2 to 4 inches (5 to 10 cm). This depth provides adequate coverage to conserve moisture, suppress weeds, and regulate soil temperature. Avoid applying mulch directly against the tree trunk to prevent issues like rot).

Timing:

The best time to apply compost is in the fall or winter, when the trees are dormant. This will give the compost time to break down and release its nutrients into the soil before the trees start growing again in the spring.

Prepare the soil:

Before applying compost, it is important to prepare the soil. This can be done by removing weeds and debris, and by loosening the soil with a shovel or rototiller.

Apply the compost:

Spread the compost evenly over the surface of the soil, around the base of the trees, and out to the drip line. The amount of compost to apply will depend on the type of compost you are using, the size of your trees, and the results of your soil test. A general rule of thumb is to apply 2-4 inches of compost.

Incorporate the compost into the soil:

Once the compost has been spread, incorporate it into the soil using a shovel or rototiller. This will help to ensure that the compost is mixed evenly throughout the soil and that it is in contact with the tree roots.

Water thoroughly:

After incorporating the compost into the soil, water the area well. This will help to activate the microbes in the compost and to start the decomposition process.

3- Compost Extract

To apply compost extract in an olive orchard, follow these steps:

Frequency:

In most cases, adjust the frequency based on the specific conditions and needs of your olive trees.

Rate:

Apply mulch at a depth of about 2 to 4 inches (5 to 10 cm). This depth provides adequate coverage to conserve moisture, suppress weeds, and regulate soil temperature. Avoid applying mulch directly against the tree trunk to prevent issues like rot).

Three rates of organic fertilizer 15 and 30 cm^3 in the form of compost extract applied as soil drench application every 15 days from March to October (Haggag, L. F. et al., 2014).

Timing:

The best time to apply compost is in the fall or winter, when the trees are dormant. This will give the compost time to break down and release its nutrients into the soil before the trees start growing again in the spring.

Prepare the soil:

Before applying compost, it is important to prepare the soil. This can be done by removing weeds and debris, and by loosening the soil with a shovel or rototiller.

Apply the compost:

Spread the compost evenly over the surface of the soil, around the base of the trees, and out to the drip line. The amount of compost to apply will depend on the type of compost you are using, the size of your trees, and the results of your soil test. A general rule of thumb is to apply 2-4 inches of compost.

Incorporate the compost into the soil:

Once the compost has been spread, incorporate it into the soil using a shovel or rototiller. This will help to ensure that the compost is mixed evenly throughout the soil and that it is in contact with the tree roots.

Water thoroughly:

After incorporating the compost into the soil, water the area well. This will help to activate the microbes in the compost and to start the decomposition process.

Protocol

Title: Comparative Study on the Effects of Two Composts on Newly Planted Olive Orchard Performance

Objective: To compare the impact of two distinct types of compost (Type A and Type B) on the growth, fruit yield, and soil quality of a newly planted olive orchard.

Duration: a multi-year study is recommended to capture changes in tree growth, fruit production, and soil health. A minimum duration of 2 years is recommended for a short-term experiment. However, for a more thorough and in-depth analysis, a long-term experiment extending over 5 years or more is advisable. Long-term studies provide valuable insights into the sustainability and lasting effects of compost application on the orchard's performance. They help account for fluctuations in tree health, fruit yield, and soil quality over extended periods.

Treatments:

- Treatment 1: Compost A- mulch
- Treatment 2: Compost A- incorporation
- Treatment 3: Compost B- mulch

- Treatment 4: Compost B- incorporation
- Treatment 5: Control

Design:

- Randomized complete block design (RCBD)

Blocks:

- 3 blocks

Variables:

- Independent variable: Types of Tree compost produced in Al Safir Orchard + Soil
- Dependent variables:
  Tree growth, fruit yield, weed growth, pest and disease incidence
  In addition to these parameters, you may also want to measure other plant growth indicators, such as stem diameter, number of leaves, and number of branches.

Monitor and record relevant environmental factors like temperature, precipitation, and weather conditions, as these variables can influence tree growth and fruit yield.

Materials:

1- Type A Compost
2- Type B Compost
3- 60 Young olive trees (of similar age and variety)
4- Soil testing kits (optional)
5- Measuring tape
6- Data recording sheets (excel sheet)
7- Gardening tools
8- Markers or sprays (waterproof)
9- Weighing scale

Experimental setup:

1- **Preparation of Compost**:
   - Obtain two different types of compost (A, and B).
   - Ensure that each type of compost is thoroughly decomposed and ready for use.
   - Calculate the quantity of needed compost after specifying the needed quantity for each tree.
2- **Select three areas** within your young olive orchard for experimentation, ensuring the three areas have similar soil types, tree varieties, and initial growth conditions.
3- **Randomly assign each of** the 4 compost treatments to one area in each block containing 4 trees. Designate a third area as a control (no compost application) for reference in each block. Each block is divided into 5 subplots each containing 4 trees assigned to one of the five treatments.

4- **Mark** each tree clearly so that you can easily identify them and track their performance over time.
5- **Measure and record** baseline data for tree growth, fruit yield, and soil conditions in all areas before the experiment begins if possible.
6- Apply Type A compost to the designated area following the two predetermined application rate and schedule. Apply Type B compost to the other designated area using the same guidelines. Avoid compost application in the control area.
Apply the composts at the same rate. The amount of compost that you apply will also affect tree performance. It is important to apply the two composts at the same rate, so that you can directly compare their effects.
7- **Collect data** on the following parameters:

- Tree growth: In September and October
    - Tree height: Measure the height of each tree at specific intervals.
    - Collar diameter: Measure the diameter of the tree 30 cm above the soil level using a caliper or any other tool if not found (thread and meter maybe).
    - Lateral shoot numbers.
- Fruit yield:
    - Fruits load was estimated visually on 10 trees per treatment, per block using five categories ranking as follows: (1) very low yield; (2) low yield; (3) medium yield); (4) high yield; and, (5) very high yield.

    - Weight or size of the harvested olives.

The data collection process involves determining the average weight of olive fruits by measuring the combined weight of 50 harvested fruits from each tree. To accomplish this, 50 mature olive fruits are carefully harvested from each tree, ensuring minimal damage. Following the harvest, the total weight of the 50 fruits from each individual fruit is measured using a precise weighing scale. Subsequently, the average weight of an individual fruit is calculated by dividing the total weight by 50. This procedure is repeated for each tree within the treatment or block.

- Maturity Index:

The maturity index was calculated according to the fruit skin color of the fruit subsamples as described by Uceda and Hermoso (1998) based on skin and pulp fruit colors, through the classification of 50 olive fruits from each selected tree into five categories based on epidermis and pulp color (0–5), with some modifications consisting on categorizing the fruits in 5 classes as follows:

- Class 1: fruits with green skin color

- Class 2: fruits with yellowish green skin color
- Class 3: fruits with less than 50% purple skin color
- Class 4: fruits with more than 50% purple skin color
- Class 5: fruits with black skin color

Then, the maturity index was calculated by the following formula:

$$MI=\frac{(0*n0)+(1*n1)+(2*n2)+(3*n3)+(4*n4)}{50}$$

Where n_0, n_1, n_2, n_3, and n_4 represent the respective counts of fruits in each color category

- Fruit quality factors such as flavor, appearance, and shelf life.

- Soil conditions: IF POSSIBLE
- Weed Growth:
  While not always a primary focus, you may choose to measure weed growth as a dependent variable, as compost can also impact weed pressure in the orchard.
- Disease and Pest Incidence:
  Observe and record the incidence of diseases and pests affecting the olive trees as dependent variables. Healthy trees are less susceptible to pests and diseases, so changes in these variables can reflect the impact of compost on tree health.
- Environmental Factors:
- Monitor and record relevant environmental factors like temperature, precipitation, and weather conditions, as these variables can influence tree growth and fruit yield to explain the cause of any aforementioned parameters.

8- **Maintain** detailed records of compost application dates, rates, and any observations or issues in the orchard.
9- **Analysis:** After several years of data collection, analyze the results to compare the effects of Type A and Type B compost and their respective way f application on young olive orchard performance. Use statistical analysis tools to assess differences between the compost types and the control area.
10- **Presentation of Results:** Present the data in tables, graphs, or charts for better visualization. Include a discussion of the implications of the findings.
11- **Conclusion:** Draw conclusions based on data analysis regarding the effects of different compost types on young olive trees. Discuss any practical implications and potential recommendations for using specific compost types in gardening or agriculture.
12- **Reporting:** Document findings in a research report or paper, including methodology, results, and discussion.

Remember to maintain consistency in all aspects of the experiment except for the type of compost used and the method of application to ensure that any observed differences are attributed to the compost type.

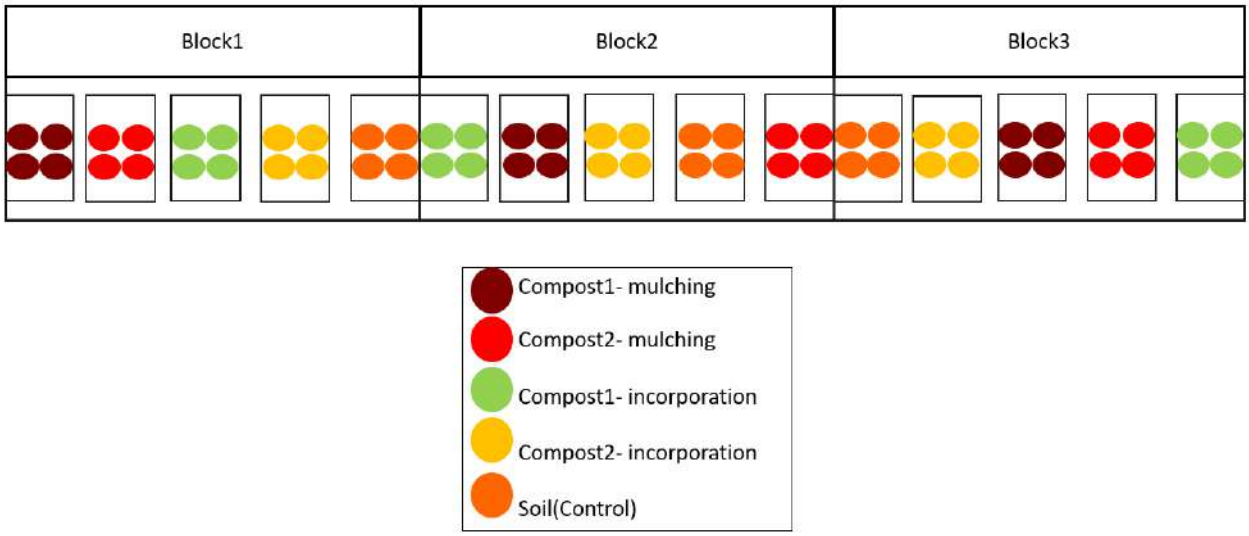
Experimental Design

- A common experimental design for this type of experiment is a randomized complete block design (RCBD). In an RCBD, the treatments are randomized within each block. This helps to reduce the effects of any variation between blocks, such as sunlight and slope for example.

- Experimental design: Randomized complete block design (RCBD)

- Treatments:
  - Treatment 1: Compost A- mulch
  - Treatment 2: Compost A- incorporation
  - Treatment 3: Compost B- mulch
  - Treatment 4: Compost B- incorporation
  - Treatment 5: Control

- Replications: 3



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Protocol 3: The Impact of Two Tree Composts on Orchard's Performance (Annona trees)

Introduction:

Annona squamosa, also known as sugar apple, is an important fruit known for its medicinal, nutritional and economic value. This has led to the increasing demand for this forest fruit, hence the need for a sustainable yet increased production. Therefore, the use of farm yard manure as an organic amendment becomes important due to its prominence in high NPK content (Onawunmi et al., 2020). G medium has been one of the most critical factors determining seedling quality especially in the nursery; the physical and chemical properties of the medium plays an important role in the retention of water, aeration which enhances the germination and emergence to the plant (Okoli et al., 2018; Onawumi et al., 2020). Composting is the process of biological decomposition of organic matter by microorganisms under controlled conditions to relatively stable humus-like material called compost. The advantages of composting to the farming system include: elimination of pathogens; reduction of volume and moisture content; reduces odor; stabilizes organic components and nutrients; and reduces soil amendment/fertilizer.

Orchard establishment is a crucial time and can shape the future of your production for many years to come. Compost and compost mulch can help young trees get off to a good start and provide you with long term benefits in increased tree growth and yield. When you are establishing your orchard, compost and compost mulch can be used in a number of different ways to benefit your plants.

One study has shown that compost can improve the yield and quality of annona fruit. In one study, annona trees that were treated with compost produced 20% more fruit than trees that were not treated. The fruit from the treated trees was also larger and had a higher sugar content (Garcia et al, 2015).

Another study found that compost can help to reduce the incidence of fungal diseases in annona trees. The compost-treated trees had fewer leaves that were infected with fungal diseases, and the fruit from these trees was also less likely to be infected (Lopez and Hernandez, 2016).

These studies suggest that compost can be a valuable tool for annona growers. By improving soil health and fertility, compost can help to increase yield, improve fruit quality, and reduce the incidence of disease.

Experimental site:

The field site at Al Safir Orcahrd in Al Ghaziyeh Area at 5.3 km from Saida (10 minutes by car), and 49 km from the Lebanese capital, at an altitude of about 50m, facing the sea,

characterized by a Mediterranean climate, characterized by hot, dry summers and mild, wet winter, with an annual amount of rainfall of 778 mm, and average annual temperature of 25°C, was selected for field experimentation. twenty-one percent of the total orchard site was planted with Annona (Golden). In 2011, 300 Annona trees were planted, but due to some technical problems in irrigation, the trees died. The cultivation of Annona was renewed around 2014-2015.

Application:

Different applications were experimented in many orchard of different cultivation, climate, soils, … In fact, all these applications fall under two main methods of compost application to tree in orchard:

1- Mulching: This is the most common way to apply compost to trees. To mulch, simply spread a layer of compost around the base of the tree, extending out to the drip line. The compost layer should be 2.5-7.5 cm thick. A variety of organic materials have been used as mulch to suppress weeds and improve soil fertility (Pinamonti, 1998; Arthur and Wang, 1999; Lu et al., 1999).

2- Incorporating into the soil: This method is less common, but it can be beneficial for young trees or trees that are struggling due to its rapid. To incorporate compost into the soil, dig a shallow trench around the base of the tree, extending out to the drip line. The trench should be about 6 inches deep. Fill the trench with compost and then backfill with soil.

In agriculture, there are two common methods for applying composts to soil: incorporation and mulching (Cogger et al., 2008). Compost incorporation into the top few centimetres increases accessibility for soil microbes and also contact with the plant roots, and thus have a greater effect on soil C, N, and bulk density than surface application (mulching)(ibid.). Mulching is a common in horticulture and agriculture in dry climates because it minimizes water loss by evaporation (Agassi et al., 1998; Gonzalez and Cooperband, 2002). Compared to incorporation, the effect of mulching on the underlying soil can be expected to be smaller as it is limited to soluble compounds leaching from the mulch layer into the soil and due to the lower accessibility to soil organisms (ibid.). Compost with a coarse texture is considered the best for mulching because it allows water and air to move through to the soil underneath. It also decomposes slowly and is therefore long-lasting. Fine textured material can also be used as mulch but if applied too thickly it can trap water and prevent it from reaching the soil; this only generally occurs if the compost is applied in a layer of more than 5cm thickness (Agassi et al., 1998; Paulin and O'Malley, 2008). Using compost extract can be a good choice especially when the quantity of compost is not sufficient to cover all the orchard. In our case, we are going to use the incorporation method and for mulching we are going to add wood chips

<u>1- How to apply Mulching:</u>

Timing:

The best time to apply compost is in the early spring or late fall, when the trees are dormant and not actively growing. Avoid applying compost during the growing season to prevent potential damage to the roots.

Soil Preparation:

- Remove any existing weeds or grass around the base of the annona trees. This will help ensure that the compost directly contacts the soil.

Apply Compost:

- Spread a layer of compost around the base of each annona tree. The depth of the compost layer can vary, but aim for at least 2-4 inches. Make sure to leave a gap around the trunk to prevent direct contact with the compost (to prevent issues like rot).

Mulch Layer:

- Optionally, add a layer of mulch on top of the compost. This additional layer helps conserve moisture, suppress weeds, and gradually breaks down to contribute organic matter to the soil.

Extend to the Drip Line:

- Extend the compost and mulch layer to the drip line of the annona tree, which is the area under the outermost branches where rainwater would naturally drip. This is where the majority of the tree's feeder roots are located.

Leave Space Around the Trunk:

- Avoid piling compost or mulch directly against the trunk of the annona tree. Leave a gap of a few inches around the base of the trunk to prevent issues like rot and pests.

Repeat Annually:

- Ideally, repeat the compost mulching process annually or as needed. Over time, the decomposing mulch and compost will contribute organic matter to the soil, improving its fertility and structure.

Water Thoroughly:

After applying the compost, water the area thoroughly. This helps the compost nutrients infiltrate the root zone and promotes settling of the compost.

2- How to apply incorporation:

Timing:

Choose an appropriate time for compost incorporation. The best time is typically in the spring or fall when the annona trees are not in active fruit production. Avoid disturbing the soil during extreme weather conditions.

Soil Preparation:

- Clear the orchard floor of any debris, weeds, or cover crops. It's important to have a clean surface for effective incorporation.

Apply Compost:

- Spread a layer of compost over the soil surface. The thickness of the layer will depend on the condition of your soil and the compost. A general guideline is to aim for a layer of about 1 to 3 inches.

Incorporate Compost:

- Use a shovel, plow, or tractor with a plow attachment to incorporate the compost into the topsoil. Turn over the soil to a depth of about 6 to 8 inches. This ensures that the compost is mixed thoroughly with the soil. Depending on the soil condition and the response of the trees, consider repeating compost incorporation on a periodic basis to maintain and enhance soil fertility.

Even Distribution:

- Try to distribute the compost evenly across the orchard. Uneven incorporation may result in inconsistent nutrient availability for the annona trees.

Avoid Trunk Contact:

- Be mindful of the tree trunks. Do not incorporate compost right up to the trunk of the annona trees. Leave a gap of several inches to prevent potential issues like rot and pests.

Rake or Harrow:

- After incorporating the compost, use a rake or harrow to level the soil surface. This step helps break down clumps, smooth the surface, and promote even water distribution.

Watering:

- Water the orchard after compost incorporation to settle the soil and provide moisture for microbial activity. Adequate moisture helps the compost integrate into the soil more effectively.

3- How to apply wood mulch + compost extract

Timing of Application:

Apply compost extract during the early morning or late afternoon to avoid the heat of the day and reduce the risk of evaporation. Consider applying compost extract every 4-6 weeks during the growing season. This interval provides a consistent supply of beneficial microorganisms and nutrients to support the trees.

Prepare Compost Extract:

- If making your own compost extract, mix compost with water in a ratio of about 1:4 or 1:5 (compost to water). Let it steep for 24-48 hours, stirring occasionally.
- Strain the mixture to remove solid particles, obtaining a liquid compost extract.

Dilution (if necessary):

- Check the concentration of the compost extract. If it's too strong, dilute it with water to achieve the desired concentration. A dilution of 1:10 to 1:20 is often recommended.

pH Adjustment:

- Measure the pH of the compost extract. Ideally, the pH should be around neutral (pH 6-7). If it's too acidic or alkaline, adjust it using natural amendments like lime or sulfur.

Weather Considerations:

- Avoid applying compost extract during heavy rain or strong winds. Aim for a calm day to ensure the extract reaches the soil and plants effectively.

Repeat Applications:

- Consider repeating the compost extract application periodically, especially during the growing season or when the soil needs a boost.

This combination of wood mulch and compost extract helps conserve soil moisture, suppress weeds, and enhance nutrient availability around the annona trees. Adjust the frequency of compost extract applications based on the specific needs of your orchard and tree health.

Protocol

Title: Comparative Study on the Effects of Two Composts on Young Annona Orchard Performance

Objective: To compare the impact of two distinct types of compost (Type A and Type B) on the growth, fruit yield, and soil quality of a young Annona orchard.

Duration: a multi-year study is recommended to capture changes in tree growth, fruit production, and soil health. A minimum duration of 2 years is recommended for a short-term experiment. However, for a more thorough and in-depth analysis, a long-term experiment extending over 5 years or more is advisable. Long-term studies provide valuable insights into the sustainability and lasting effects of compost application on the orchard's performance. They help account for fluctuations in tree health, fruit yield, and soil quality over extended periods.

Treatments:

- Treatment 1: Compost A- wood mulch + extract
- Treatment 2: Compost A- incorporation
- Treatment 3: Compost B- wood mulch + extract
- Treatment 4: Compost B- incorporation
- Treatment 5: Control

Design:

- Randomized complete block design (RCBD)

Blocks:

- 3 blocks

However, using 3 blocks will reduce the power of the experiment and make it less likely to detect significant differences between the treatments. In general, more blocks will lead to a more powerful experiment and a greater chance of detecting significant differences between treatments. However, more blocks also mean more work and more resources.

Variables:

- Independent variable: Types of Tree compost produced in Al Safir Orchard + Soil
- Dependent variables: Tree height, trunk diameter, Branch diameter, Fruit yield, Fruit weight (diameter), Root collar diameter, number of leaves,...

  Monitor and record relevant environmental factors like temperature, precipitation, and weather conditions, as these variables can influence tree growth and fruit yield.

Materials:

1- Type A Compost

2- Type B Compost

3- Wood chips

4- Bucket

5- Strainer or mesh bag

6- Stirring stick

7- () Young annona trees (of similar age and variety)

8- Soil testing kits (optional)

9- pH paper (optional)

10- Measuring tape

11- Data recording sheets (excel sheet)

12- Gardening tools

13- Markers (waterproof)

14- Weighing scale

15- Caliper

Experimental setup:

1- Preparation of Compost:

- Obtain two different types of compost (A, and B).
- Ensure that each type of compost is thoroughly decomposed and ready for use.
- Calculate the quantity of needed compost after specifying the needed quantity for each tree.
- Prepare compost extract as mentioned above.

2- Select five areas within your young annona orchard for experimentation, ensuring the five areas have similar soil types, tree varieties, and initial growth conditions.

3- Randomly assign the four treatments to each area. Designate a fifth area as a control (no compost application) for reference in each block. Each block is divided into 5 subplots each containing 4 tees assigned to one of the five treatments.

4- Mark each tree clearly using a marker on the trunk so that you can easily identify them and track their performance over time.

5- Measure and record baseline data for tree growth, and soil conditions in all areas before the experiment begins if possible.

6- Apply each treatment to the designated area following the two predetermined application rate and schedule. Avoid compost application in the control area.

- For wood mulch + extract

Apply the composts at the same rate. The amount of compost that you apply will also affect tree performance. It is important to apply the two composts at the same rate, so that you can directly compare their effects.

7- Collect data on the following parameters:

- Tree growth:
  - Tree height: Measure the height of each tree once each year.
  - Collar diameter: Measure the diameter of the tree 30 cm above the soil level using a caliper or any other tool if not found (thread and meter maybe).

- Fruit yield:
    - Number of apples harvested per tree.
    - Weight or size of the harvested annona.
    - Fruit quality factors such as flavor, appearance, and shelf life.
- Soil conditions: IF POSSIBLE
- Weed Growth:

While not always a primary focus, you may choose to measure weed growth as a dependent variable, as compost can also impact weed pressure in the orchard.

- Disease and Pest Incidence:

Observe and record the incidence of diseases and pests affecting the annona trees as dependent variables. Healthy trees are less susceptible to pests and diseases, so changes in these variables can reflect the impact of compost on tree health.

- Environmental Factors:
- Monitor and record relevant environmental factors like temperature, precipitation, and weather conditions, as these variables can influence tree growth and fruit yield to explain the cause of any aforementioned parameters.

8- Maintain detailed records of compost application dates, rates, and any observations or issues in the orchard.

9- Analysis: After several years of data collection, analyze the results to compare the effects of Type A and Type B compost on young annona orchard performance. Use statistical analysis tools to assess differences between the compost types and the control area.

10- Presentation of Results: Present the data in tables, graphs, or charts for better visualization. Include a discussion of the implications of the findings.

11- Conclusion: Draw conclusions based on data analysis regarding the effects of different compost types on young apple trees. Discuss any practical implications and potential recommendations for using specific compost types in gardening or agriculture.

12- Reporting: Document findings in a research report or paper, including methodology, results, and discussion.

Remember to maintain consistency in all aspects of the experiment except for the type of compost used and the method of application to ensure that any observed differences are attributed to the compost type.

Expected Outcomes

This experiment is expected to provide valuable information on the effects of different types of compost on the growth and development of young annona trees. The results of this experiment can be used to optimize compost application strategies for annona growers, leading to increased productivity and profitability.

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Protocol 4: The Impact of Two Tree Composts on Carob Seeds' Germination and Growth

Introduction:

Carob trees (Ceratonia siliqua) have a rich history and continue to play a significant role in South Lebanon's agricultural landscape. These iconic trees, often referred to as "kharrub" in Arabic, have been cultivated in the region for centuries. Historically, carob pods were valued for their sweet, nutritious pulp, which served as a traditional food source and was used as a natural sweetener. Carob trees were also prized for their role in stabilizing and enriching the region's soil. Over time, however, the cultivation of carob trees in South Lebanon faced challenges, including changes in agricultural practices and a shift towards more modern crops.

In recent years, there has been a renewed interest in carob cultivation in South Lebanon due to its adaptability to the local climate and its potential economic and environmental benefits. Carob-based products, such as carob powder and syrups, are gaining popularity as healthier alternatives to processed sweeteners, contributing to the revival of carob farming. Additionally, carob trees are recognized for their ability to improve soil quality and contribute to sustainable agriculture, making them an important component of agroforestry and environmental conservation efforts in the region. As South Lebanon embraces the potential of carob cultivation, these ancient trees continue to leave their mark on the region's cultural and agricultural heritage.

Planting Carob Seeds as it offers numerous advantages to both farmers and the local environment. South Lebanon's Mediterranean climate, characterized by mild winters and dry summers, is well-suited for carob cultivation. Carob trees are drought-resistant, making them a sustainable crop in this region with limited water resources. The pods produced by carob trees have multiple uses, from being a nutritious food source for humans to serving as animal feed. This versatility in utilization can provide economic opportunities for farmers. Furthermore, carob trees help improve soil quality through their deep root systems, assist in erosion control on slopes, and contribute to carbon sequestration, aiding in climate change mitigation. As a culturally significant and environmentally beneficial crop, planting carob seeds in South Lebanon aligns with the region's agricultural heritage while promoting sustainable agriculture and economic growth.

Carob seeds are typically planted when the soil temperature is consistently between 15 and 20 °C. This generally occurs in South Lebanon during the fall months, particularly in October and November, which makes it an excellent option for our trail.

Life Cycle of Carob

The life cycle of a carob seed (Ceratonia siliqua) can be broken down into several stages, typically measured in months. Keep in mind that the timing of these stages can vary depending on environmental conditions, such as temperature and soil quality. Here's a general overview:

1. **Seed Formation (0 months):**
    - The carob tree produces seeds as part of its reproductive cycle. This stage begins when the flowers are pollinated.
2. **Seed Dormancy (0-6 months):**
    - Carob seeds have a hard seed coat that often requires scarification (mechanical or chemical treatment) to break dormancy and promote germination.
    - Some carob seeds may remain dormant for up to six months or more before they start to germinate.
3. **Germination (6-12 months):**
    - Once the dormancy is broken, carob seeds typically begin to germinate. This stage can take anywhere from six to twelve months or longer, depending on various factors.
    - Germination usually occurs when soil temperature and moisture levels are suitable.
4. **Seedling Growth (12-18 months):**
    - After germination, carob seeds develop into seedlings. During this stage, they produce their first true leaves and start establishing a root system.
    - Seedlings require appropriate soil, sunlight, and water to grow.
5. **Young Tree (18-36 months):**
    - As the carob seedlings mature, they become young trees.
    - This stage can last anywhere from 1.5 to 3 years, depending on growing conditions.
    - Young carob trees still require care and maintenance to ensure healthy growth.
6. **Maturity (5-15 years):**

- Carob trees typically become mature and start producing their first pods when they are 5 years old, but its highest productivity is noticed starting its 10^{th} year.
- The time to maturity varies widely based on factors such as soil quality, climate, and growing conditions.

7. **Pod Production (10+ years):**
    - Once mature, carob trees can produce pods annually for many years, often for several decades.
    - Pod production can continue for the lifespan of the tree, which may be over 100 years.
    - The carob pods can be harvested in the fall, once they have turned brown and dried out.
    - The carob pods can be eaten fresh or dried, and the seeds can be ground into flour or used to make carob powder.

It's important to note that the timing of these stages can vary significantly depending on environmental conditions and individual tree health. Carob trees are known for their longevity and resilience, making them valuable additions to agricultural and agroforestry systems in regions where they thrive.

Germination:

Its seeds are dispersed in nature by animals that feed on them, which makes the seed coat permeable to water, with a germination rate not exceeding 10%, or the seed may decompose or germinate as a result of contact with soil particles (F. J. Pérez-García (2009), B. Piotto et al. (2003)). Ceratonia siliqua seeds have a hard coating, which makes their germination very slow. Before agriculture, the seed is treated with various treatments that reduce the hardness of its cover and help it to **imbibition water to be germinated** (H. Gubbuk et al. (2011)). Several studies indicated the success of many treatments in breaking the dormancy of Ceratonia siliqua L. seeds, as a local study showed that treatment of seeds by scarifying with **soaking in gibberellin** 500ppm gave a germination percentage of 98% (S. M. Salih et al. 2018))). A result of a study in Greece showed that treatment of seed to **soaking sulphuric acid for 15 minutes** would an increase germination rate to 86% in 10 days (M. Tsakaldimi et al. (2001)), and the seeds **soaking in alcohol for 60 minutes** recorded a germination rate of 50% (W. Mansour (2013)).

Germination Test

A germination test for carob seeds using cotton is a simple and effective method to determine the germination rate of the seeds.

Materials Needed:

1. Carob seeds

2. Cotton balls or cotton pads

3. Plastic containers with lids (you may use petri dishes or a glass container, …)

4. Water

5. Labels and markers

Procedure:

- Gather all the materials needed for the germination test.

- Select a representative sample of carob seeds that you want to test for germination. Ensure that the seeds are clean and free from damage or disease.

- Moisten the cotton balls or cotton pads with water. Ensure that they are damp but not soaking wet. Excess water can lead to seed rot.

- Place the moistened cotton in the bottom of the plastic or glass containers to create a uniform, moist bed for the seeds.

- Carefully place the carob seeds on top of the moistened cotton. Space the seeds evenly, leaving some space between them to allow room for growth.

- Place the lids on the containers to create a humid microenvironment for the seeds.

- Place the containers in a warm, well-lit location but away from direct sunlight. A temperature of around (15-25°C) is generally suitable for germinating carob seeds.

- Check the containers daily to ensure that the cotton remains moist. Add water if necessary but be careful not to oversaturate it.

- Record the number of seeds that germinate each day and remove any seeds that show signs of mold or fungal growth.

- Continue to observe and record seed germination for an appropriate duration. Carob seeds may take 7-14 days or longer to germinate, depending on conditions.

i Germination Rate (%) = (Number of Germinated Seeds / Total Number of Seeds Tested) x 100

Germination tests

In October 5 I performed a germination test for Carob seeds using 4 treatments (alcohol, scarification, H2SO4, and hot water)

Each 25 seeds were treated separately and kept moist on a cotton base for 2 weeks. After 2 weeks on October 18, germination of seeds was observed for each treatment to determine the most appropriate treatment that can be used in Al-Safir, and the results are as follows:

- **Alcohol: 5/25**
- **Scarification: 21/25**
- **H2SO4: 3/25 germination and 9/25 only get enlarged without germinating**
- **Hot water: 9/25 germinated and 7/25 only get enlarged without germinating**

Protocol

Title: Effect of Compost Type on Carob (Ceratonia siliqua) Seed Germination and Growth

Objective: To determine the influence of two different types of compost (Compost A and Compost B) on the germination and growth of carob seeds.

Duration: the duration can last from 4-8 weeks to months depending on the desired duration chosen to observe and monitor growth.

Treatments:

- Treatment 1: Compost A
- Treatment 2: Compost B
- Treatment 3: Control (no compost)

Design:

- Randomized complete block design (RCBD)

Blocks:

- 4 blocks, or 3 blocks

However, using 3 blocks will reduce the power of the experiment and make it less likely to detect significant differences between the treatments. In general, more blocks will lead to a more powerful experiment and a greater chance of detecting significant differences between treatments. However, more blocks also mean more work and more resources.

Replications:

- 3 replications per treatment per block

Total number of pots:

- 36 pots (3 treatments * 4 blocks * 3 replications)

Variables:

- Independent variable: Types of Tree compost produced in Al Safir Orchard
- Dependent variables: Seed germination rate, seedling height, seedling weight, root length, leaf area, time to germination, survival rate,…)
  In addition to these parameters, you may also want to measure other plant growth indicators, such as stem diameter, number of leaves, and number of branches.

Materials:

1. Carob seeds (fresh and viable)
2. Compost A
3. Compost B
4. Potting soil (as a control)
5. Planting pots (36)
6. Labels and markers (waterproof)
7. A marked stick to ensure all seeds are planted at a depth of …cm.
8. Potting soil or garden soil (control group)
9. Watering can or spray bottle
10. Ruler or measuring tape
11. Light source (e.g., natural sunlight)
12. Timer to establish a regular watering schedule, and keep track of time of data collection
13. Data recording sheet (excel sheet) or notebook
14. Weighing scale
15. Nylon shield

Experimental setup:

1- Preparation of Compost:
   - Obtain two different types of compost (A, and B).
   - Ensure that each type of compost is thoroughly decomposed and ready for use.

2- Seed Selection: Try using seeds of similar size and ensure they are fresh and viable. Ensure you have a sufficient number of carob seeds of similar size and quality.

3- Experimental Groups: Divide the planting pots into groups, 12 for each compost type and a control group with potting soil (without compost). Label each group accordingly.

4- Compost Application: Apply different compost types to their respective groups following the experimental design assigned below.

5- Plant an equal number of soaked carob seeds in each pot within their respective treatment group. You can plant multiple seeds per pot (4 seeds), but make sure to record the number of seeds planted.
   For consistency, use the same depth and spacing for all pots.

6- Place all groups in an environment with controlled temperature and light conditions. Aim for a consistent temperature (15- 25°C) and provide adequate light (natural or artificial) for germination.

7- Ensure that all groups receive the same amount of light and are exposed to it for the same duration each day.
8- Water the seeds. Water the seeds well, and keep the growing medium moist throughout the germination and growth period.
9- Place the pots in a warm, sunny location. Carob seeds need warmth and sunlight to germinate and grow.
10- Monitor the germination and growth of the carob seeds. Measure the number of seeds that germinate in each pot, and the height and weight of the seedlings at regular intervals.
11- Keep the soil or compost consistently moist but not waterlogged. Water all groups with the same amount of water when necessary. You can use a spray bottle to avoid disturbing the seeds.
12- Data collection:
Regularly monitor and record the following data for each treatment group:

- **Date of planting**
- **Germination Rate:**
Measure the number of seeds from each treatment group that have successfully germinated. Germination is typically defined as the emergence of the first shoot (radicle) from the seed.
Be patient! It may take several weeks for the seeds to germinate. You should monitor them every other week; typically it will start after 2 weeks.
The germination time will depend on a number of factors, including the temperature, humidity, and the quality of the seeds.
- **Seedling weight:**
Fresh weight of external plant parts and roots. Three plants in each treatment and seed site were collected; the root system was washed carefully with tap water. External plant parts and roots were separated then weighted for counting fresh weights.
- **Leaf area:**
It might be a complex issue and require tools that are not available, so we can measure the length and width instead.
- **Seedling Height:**
Measure the height of five carob seedlings using a ruler every 15 days during 3 months, from the soil surface to the tip of the main stem. This measurement provides insight into the vertical growth of the plants.
- **Leaf Count:**
Count the number of leaves of five carob seedlings every 15 days during 3 months, This parameter indicates the development of foliage and can help assess the overall health and vigor of the plants.
- **Total root system branching:**
All roots part of the three sampled seedlings used previously was washed with tap water. Total root system branching was determined by numbering of all root branches besides the principal root length was measured with a ruler.
- **Stem Diameter:**

Measure the diameter of the main stem of five carob seedlings every 15 days during 3 months, using a caliper or ruler. Stem diameter can be an indicator of plant strength and robustness.

- **Fresh weight:**
  At the end of the experiment, harvest and dry the seedlings from each treatment group. Weigh the dried biomass to assess differences in overall plant growth and development.
- **Time to Germination:**
  Record the number of days it takes for each seed to germinate. This parameter can provide information on the speed of germination for each compost type.
- **Vigor Index:**
  Calculate a vigor index, which is a combination of parameters such as germination rate, seedling height, and leaf count. This index provides a comprehensive assessment of plant health and growth.
- **Disease or Pest Incidence:**
  Monitor the seedlings for any signs of disease or pest infestations. Note if one compost type appears to be more resistant to such issues.
- **Survival Rate:**
  Calculate the percentage of seedlings that survive until a specified point in the experiment (e.g., after 4 weeks after germination). This parameter considers both germination and subsequent growth.
- **Color and Visual Observations:**
  Note any differences in plant color, shape, or overall appearance between the treatment groups. This qualitative assessment can provide valuable insights into the health and stress levels of the plants.
- **Morphological Characteristics:**
  Examine and record any unique morphological characteristics, such as the presence of lateral roots, branching patterns, or abnormalities.

13- Data Analysis: After a predefined period (e.g., 4-6 weeks), compare the germination rates and growth of carob seedlings in each group.
14- Statistical Analysis: Perform statistical tests using R and SPSS softwares to determine if any observed differences are statistically significant.
15- Presentation of Results: Present the data in tables, graphs, or charts for better visualization. Include a discussion of the implications of the findings.
16- Conclusion: Draw conclusions based on your data analysis regarding the effects of different compost types on green pea seeds. Discuss any practical implications and potential recommendations for using specific compost types in gardening or agriculture.
17- Reporting: Document your findings in a research report or paper, including your methodology, results, and discussion.

Remember to maintain consistency in all aspects of the experiment except for the type of compost used to ensure that any observed differences are attributed to the compost type.

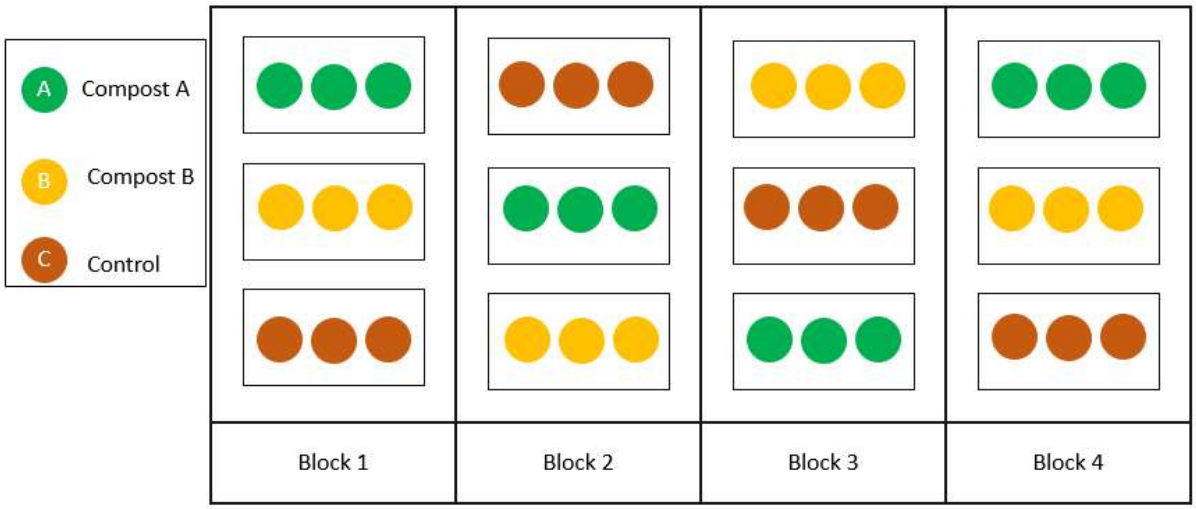
Experimental Design

- A common experimental design for this type of experiment is a randomized complete block design (RCBD). In an RCBD, the treatments are randomized within each block. This helps to reduce the effects of any variation between blocks, such as sunlight for example.

- Experimental design: Randomized complete block design (RCBD)

- Treatments:
Control (no compost)
Compost type 1: A
Compost type 2: B

- Replications: 4



Protocol 5: The Impact of Two Tree Composts on Strawberry Seedlings' Growth

I. Introduction:

Agriculture is a cornerstone of food production and sustenance worldwide, and within this realm, optimizing crop growth and yield is an ongoing pursuit. Soil quality and nutrient availability play pivotal roles in determining the success of agricultural endeavors. Composting, a natural process of converting organic waste into nutrient-rich humus, has gained recognition as a sustainable and environmentally responsible approach to soil enrichment. In this context, this experiment seeks to explore the potential benefits of compost on the growth and development of strawberry seedlings, a valuable and widely cultivated crop. By examining the effects of two distinct compost types in comparison to a control group of soil alone, we aim to unravel the influence of compost quality on the early stages of strawberry seedling growth. This investigation not only holds relevance for farmers and horticulturists but also contributes to our understanding of sustainable agricultural practices and the pivotal role of composting in modern agriculture.

Strawberry is one of the plant materials that responds quickly to new applications and is frequently used in new plant nutrition material trials (Say ˘gı, H. ,2022). Strawberry is suitable for all levels: individuals as a hobby and small or large businesses for commercial purposes. Strawberry, with its unique appearance, taste-aroma and red color, is an important food source for human health with its rich antioxidant properties and vitamin and nutritional element content (Taghavi, T. et al. 2019, Quarshi, H.Q et al. 2023).

Strawberries are planted in Lebanon in the fall, typically from October to December. This allows the plants to establish themselves before the hot and dry summer weather. Strawberry plants are perennials, so they can produce fruit for several years. However, the best yields are typically produced in the first two to three years.

In Lebanon, strawberries are grown in both open fields and greenhouses. Greenhouses allow growers to control the growing environment and extend the strawberry season. Strawberries grown in greenhouses are typically available from November to May. Strawberries grown in open fields are typically available from May to July. It is in great demand as it is always consumed as a fresh or processed product by consumers at any time of the year.

Here is a more detailed timeline of the strawberry growing season in Lebanon:

- October to December: Strawberries are planted.
- January to March: The plants establish themselves and start to produce flowers.

- April to May: The strawberries start to ripen and are ready for harvest.
- June to July: The strawberry season ends.

II. Life cycle:

1- Fall (October-December)

- Plant strawberry seeds or seedlings
- Strawberry plants go dormant

2- Winter (January-March)

- Strawberry seeds are cold-stratified
- Strawberry plants remain dormant

3- Spring (April-June)

- Strawberry seeds germinate
- Strawberry plants emerge from dormancy
- Strawberry plants produce flowers
- Strawberry plants produce fruit

4- Summer (July-September)

- Strawberry fruit ripens
- Strawberry plants produce runners

5- Fall (October-December)

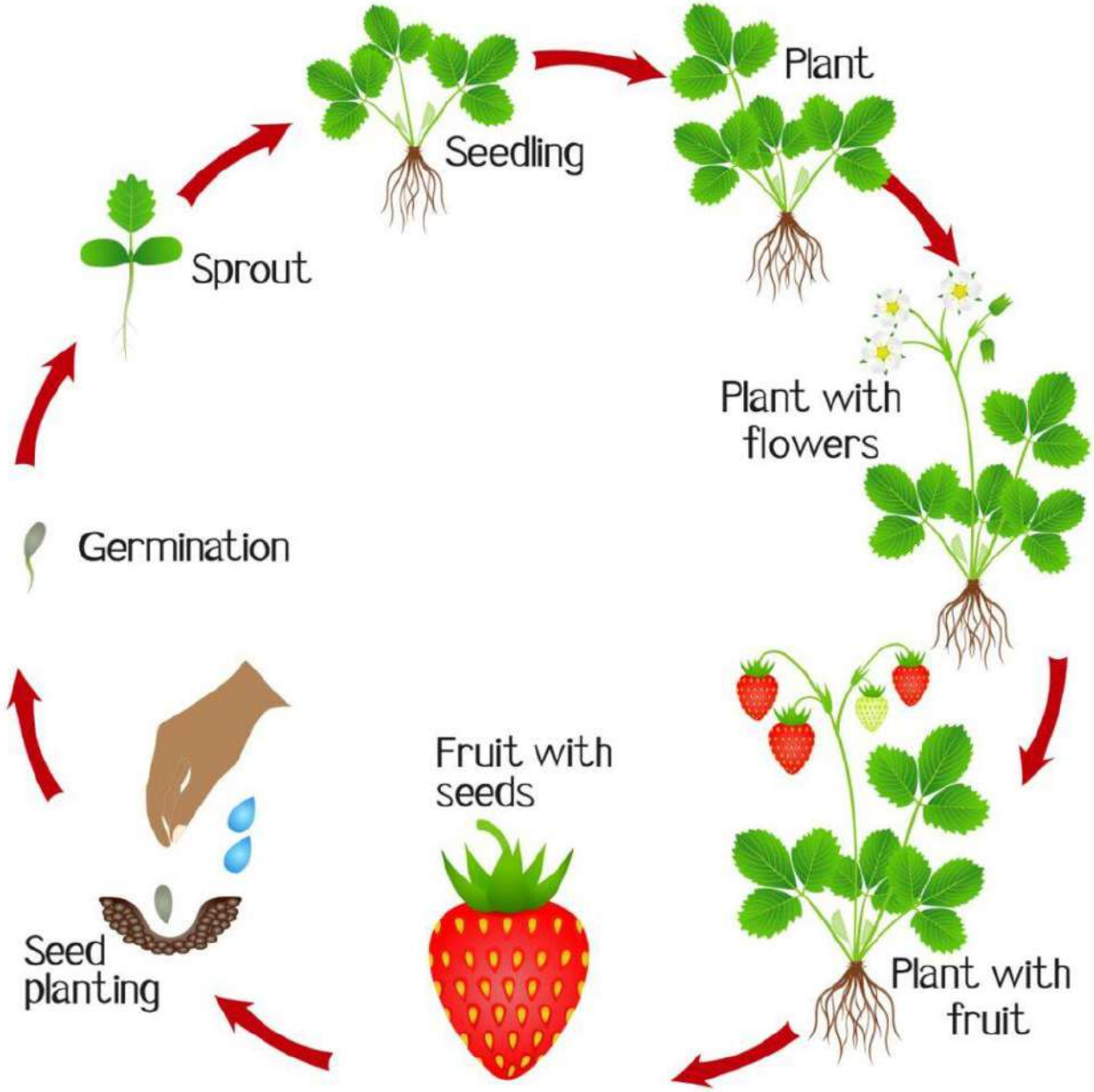
- Strawberry plants go dormancy

Variety:

Strawberry Variety: Cadonga

If this protocol application is postponed, spring varieties must be chosen by visiting this this website:

وزارة الزراعة - الفريز (agriculture.gov.lb)



The figure shows the six stages of the strawberry life cycle:

1. Seed- 6-8 weeks
2. Seedling- 2-3 months
3. Runner- 1-2 months
4. Flower- 1-2 weeks
5. Fruit- 3-4 weeks
6. Senescence- 2-3 years

The number of days needed for each phase of the strawberry life cycle will vary depending on the climate and the variety of strawberry plant. However, here is a general guideline:

III. Protocol

Protocol to measure the effect of different compost applications on strawberry seedlings

- **Title**: Assessing the Impact of Different Compost Types on the Growth of Strawberry Seedlings

- **Objective**: To determine how different compost types affect the seedling growth, and overall development strawberry.

- **Duration**: depends on the environmental conditions and the time of the experiment but may extend to several months

- Variables:

- Independent variable: Types of tree compost produced in Al Safir Orchard (2 types)
- Dependent variables: plant height, leaf count, root development, flowering, fruit development, taste, …

- Materials:

1. Strawberry seedlings of the same variety (Cadonga)
2. Two types of compost (the 2 types of tree composts produced at Al Safir orchard)
3. Potting soil or garden soil (control group)
4. Planting containers (45 pots)
5. Labels and markers
6. Measuring tools (ruler or measuring tape)
7. Watering can or hose
8. Light source (natural sunlight or artificial grow lights)
9. Data recording sheets (excel sheet)
10. Neylon cover to protect the flowers from frost

- **Experimental Setup:**

1- Treatments:

Treatment 1: Strawberry seedlings planted in pots filled with Compost 1 produced in Al Safir Orchard+ Soil (1:1).
Treatment 2: Strawberry seedlings planted in pots filled with Compost 2 produced in Al Safir Orchard + Soil (1:1).
Treatment 3: Strawberry seedlings planted in pots filled with soil and receiving Compost 1 extract.
Treatment 4: Strawberry seedlings planted in pots filled with soil and receiving Compost 2 extract.
Treatment 5 (Control): Strawberry seedlings planted in pots filled with soil only.

2- Randomization:

Randomly assign strawberry seedlings to each treatment group to minimize bias.

3- **Replication:**
Create multiple replicates of each treatment group. The number of replicates will depend on the statistical power you desire, but having at least three replicates per treatment is a good starting point.

4- **Plant Selection:**
Select healthy strawberry seedlings of the same variety and similar size for uniformity.

5- **Pot Selection:**
Use identical pots or containers for all treatments to ensure consistency.

6- **Preparation of Compost:**
   - Obtain two different types of compost (CA, CB).
   - Ensure that each type of compost is thoroughly decomposed and ready for use.
   - Composts should be screened for large debris and uniform in texture, to remove unfinished materials and minimize the incidence of weed seeds, ensure aeration, good water retention and nutrient distribution.
   - Compost is applied in 3 different ways:
     - Compost + soil mixture
     - Compost extract
     - Control
   - So in total 5 treatments

Compost 1	Compost 2	Control
Compost + soil mixture	Compost + soil mixture	Soil
Compost extract	Compost extract	

7- **Planting Procedure:**
Plant each strawberry seedling according to the treatment group's specifications (compost 1 and compost 2)
Ensure that planting depth, spacing, and watering are consistent for all seedlings.

8- **Applying compost extract:**
You can apply compost extract (1 part extract to 10 parts water) to strawberry plantlets every 2-3 weeks during the growing season. It is best to apply the extract in the morning or evening, when the sun is not shining directly on the plants.
You can apply compost extract more frequently, it is best to dilute it more. For example, you can dilute the extract with water at a ratio of 1 part extract to 20 parts water. You can also apply the extract less frequently, such as once a week or every 10 days.

9- **Environmental Control:**
Maintain consistent environmental conditions, including temperature, humidity, and light exposure, to minimize external influences on seedling growth.

10- **Data Collection:**
Implement a regular data collection schedule to record the following parameters:

- Plant height: was determined by measuring the highest point of the plants from the base to the tip of the main stem.
- Presence of flowers or fruit (if applicable).
- Days to flowering
- Days to fruiting
- Fruit weight: was weighed by counting all the fruits obtained from each replication, and the average fruit weight was expressed in g
- The number of fruits per plant was calculated by counting the fruits harvested from each plot and dividing by the number of plants in each plot
- To calculate the yield per plant, all harvested fruits in each plot were weighed with a digital scale, and the yield values of each plot were determined. Afterwards, these values were divided by the number of plants in each plot and yield values per plant were obtained and expressed as g plant−1.
- The number of stems and stem numbers of the plants at the end of the harvest were determined, and the average number of stems per plant was determined.
- The number of leaves was determined as the average number of leaves per plant by counting the leaves of the plants at the end of the harvest.
- At the end of harvest, five plants at the same developmental level in each replication were removed without damaging their roots (approximately 95%), and root lengths were measured.
- The average plant width was determined by measuring the widest part of the vegetative part of the plants at the end of the harvest.

11- Data Analysis:

Analyze the collected data statistically, comparing the growth parameters of seedlings across the three treatment groups (homemade compost, commercial compost, and soil-only control). Use appropriate statistical tests, such as t-tests or analysis of variance (ANOVA), to determine if significant differences exist between groups.

12- Duration:

The experiment's duration will depend on the specific research objectives and the growth stage that I aim to study that is agreed on. A plan for a sufficient time frame, which may range from a few weeks for early growth measurements to several months should be set if I want to observe fruit-bearing.

13- Controls:

Implement control measures to account for variables other than compost that might influence seedling growth. This includes consistent watering, environmental monitoring, and soil quality checks.

14- Data Recording and Reporting:

Record all data meticulously and prepare a formal report summarizing the experiment, including background, methodology, results, and conclusions. Use tables and graphs to present your findings clearly.

How to prepare a compost extract?

To prepare compost extract, you will need:

- 1 gallon of water
- 1 cup of finished compost
- A cheesecloth or fine mesh strainer
- A large container to mix the extract in
- A bucket or sprayer to apply the extract

Instructions:

1. Place the compost in a mesh bag and knead it in the large container and add the water.
2. Stir the mixture vigorously for 1-2 minutes.
3. Cover the container and let it steep for 24-48 hours, stirring occasionally.
4. Strain the extract into the bucket or sprayer.
5. Dilute the extract with water at a ratio of 1 part extract to 10 parts water.
6. Apply the extract to the soil around your plants, using the bucket or sprayer.

You can apply compost extract to your plants every 2-3 weeks during the growing season. It is best to apply the extract in the morning or evening, when the sun is not shining directly on the plants.

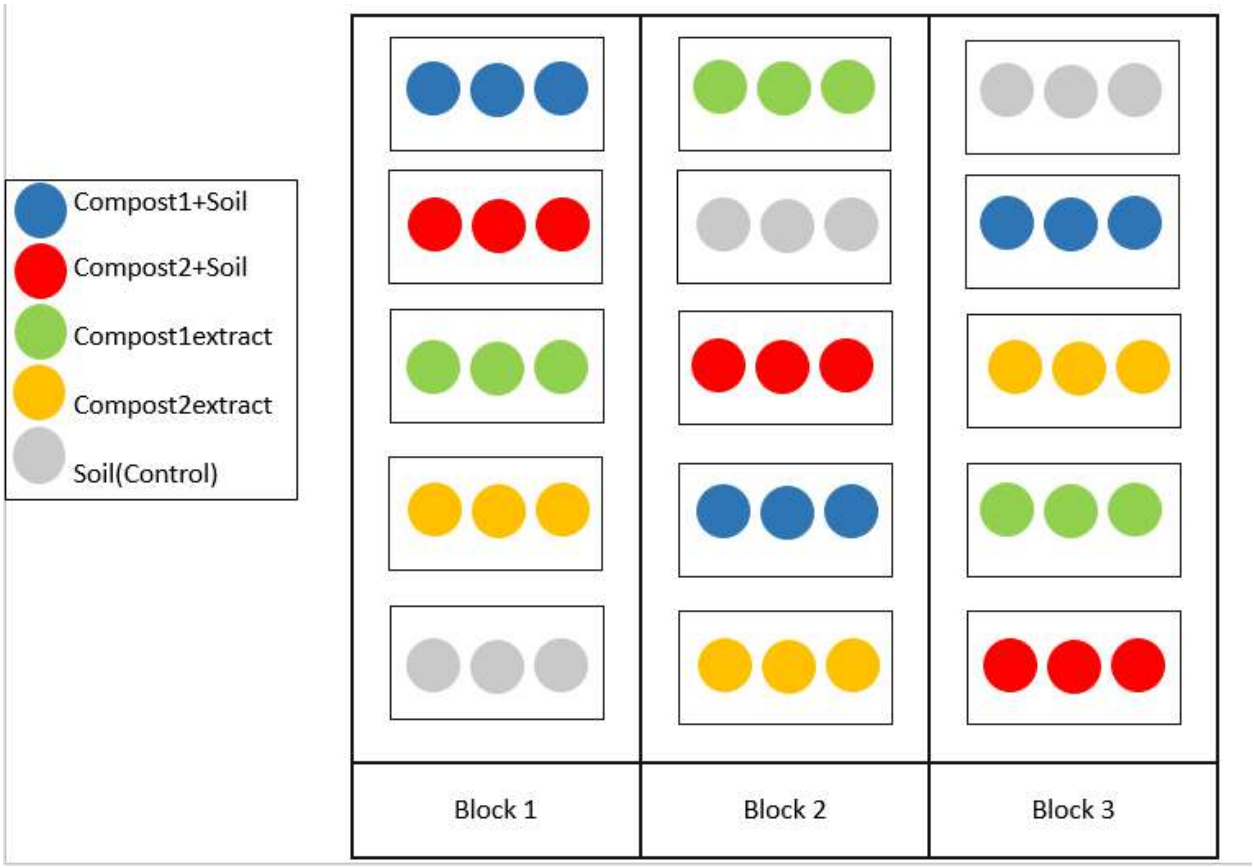
Experimental Design

- A common experimental design for this type of experiment is a randomized complete block design (RCBD). In an RCBD, the treatments are randomized within each block. This helps to reduce the effects of any variation between blocks, such as sunlight for example.

- Experimental design: Randomized complete block design (RCBD)

- Treatments:
  - Compost 1+ Soil
  - Compost 2+ Soil
  - Compost 1 extract
  - Compost 2 extract
  - Soil(Control)

- Replications: 3



References

1- مشروع التنمية الزراعية الممول من إلتحاد أألوروبي AGRICULTURAL DEVELOPMENT PROJECT MED/2003/5715/ADP

Protocol 6: The Impact of Different Composts on Seed's Germination and Growth (Basil seeds)

Protocol

- **Title**: Assessing the Impact of Different Compost Types on the Germination and Growth of Basil Seeds

- **Objective**: To determine how different compost types affect the germination rate, seedling growth, and overall development of basil seeds

- **Duration**: 30 days

Sample Timeline:

- **Day 1-10:** Germination phase and early seedling growth.
- **Day 10-20:** Continued seedling growth and development.
- **Day 20-30:** Advanced seedling growth and potential flowering (depending on basil variety).
- **Day 30+:** Mature basil plants, potential harvest, and conclusion of the experiment.

- **Variables**:

- Independent variable: Types of vegetables compost produced in Al Safir Orchard (3 types)
- Dependent variables: Seed germination rate, plant height, leaf count, root development, biomass, weed incidence,…

- Materials:

1. Basil seeds
2. Different types of compost (the 3 types of seed composts produced at Al Safir orchard)
3. Planting pots (72 pot)
4. Potting soil or garden soil (control group)
5. Labels and markers (waterproof)
6. Spray bottle
7. Ruler or measuring tape
8. Light source (e.g., natural sunlight or grow lights)
9. Timer to establish a regular watering schedule, and keep track of time of data collection (Google calendar reminder is used here)
10. Data recording sheet (excel sheet) or notebook

- **Experimental Setup**:

13- Preparation of Compost:
    - Obtain three different types of compost (C1, C2, C3).
    - Ensure that each type of compost is thoroughly decomposed and ready for use.

14- Seed Selection: Try using uniform seeds.

15- Experimental Groups: Divide the planting pots into groups, 18 for each compost type and a control group with potting soil (without compost). Label each group accordingly.

16- Compost Application: Apply different compost types to their respective groups following the experimental design assigned below.

17- Planting: Plant basil seeds (basil seeds are tiny so it is difficult to count them, try adding constant amount) in each pot. Be sure to plant the seeds at a shallow depth in all of the pots.

18- Watering: Water all groups evenly to maintain consistent soil moisture levels. Use a spray bottle to avoid disturbing the seeds. But be careful not to overwater them. The potting medium should be moist, but not soggy.

19- Place all pots in a location where they receive the same amount of light (natural sunlight or under grow lights).

20- Maintain consistent temperature conditions throughout the experiment.

21- Data Collection:
    - Record the following parameters regularly throughout the experiment.
    - During the experimentation, six plants under each treatment combination (from the three blocks) were randomly selected and tagged for recording the observation on growth and yield characters (whenever required). Do not remove any part of these plant before the end of the experiment.
    - Record the date when the seeds were planted (Day 0).
    - On a data recording sheet, create a table or list where you can record the data collected. Label each measurement with a unique identifier.

a. Days taken to germination: After sowing, each plot was regularly watched to record the number of days taken for full germination (1-10 days).
b. Germination rate: Keep monitoring the containers daily, and record the number of germinated seeds daily. After the monitoring period is complete, calculate the germination rate using the following formula:
   Germination Rate (%) = (Number of Germinated Seeds / Total Number of Seeds Planted) x 100
c. Plant height: Height of the six **tagged** plants from each treatment were recorded from ground level to the tip of apical buds at last picking stage and then averaged to get mean heights. Measure and record the height of each green pea plant at regular intervals (every 10 days) until the end of the experiment. Plant height was measured

every 10 days for one plant per plot, with a total of six plants per treatment. **Make sure to measure the height of the same plants every 10 days.**

d. Root length: If you can carefully extract a plant without causing damage, examine and record the root development. Healthy roots are typically white and well-branched.
e. Plant vigor: The vigor of the seedlings was determined by following the formula of Abdul-Baki and Anderson (1973). Vigor index = [mean of root length (cm) + mean of shoot length (cm)] × percentage of seed germinations. (30-50 day/ at the end of the experiment)
f. Plant morphology: Monitor and record any visible differences in plant health, leaf color, and overall growth.
g. Leaf Count: Count the number of leaves on each seedling to assess the development of the basil plants over time.
h. Plant Biomass: Weigh the seedlings or record their mass as they grow to determine if there are differences in overall plant growth and biomass between the compost types.
i. Yield per plant: At time of maturity and harvest (30- 50 days), measure the yield of radishes produced by each compost type. This is particularly relevant if you are interested in the practical implications for crop production
j. Branching: you may count the branches if possible.
k. Incidence of weed: State whether for each type of compost there is weed emergence. If yes, try counting the number of seedlings from 6 pots for each treatment.
l. Disease Incidence: Monitor the seedlings for any signs of diseases or pests, and record whether certain composts seem to affect the susceptibility of the plants to these issues.
m. Visual Observations: Make qualitative observations about the overall health and appearance of the radish plants, including color, size, and any abnormalities.

9- Data Analysis: After an appropriate growth period (e.g., several weeks), analyze the data collected, looking for differences in germination rates, seedling growth, and overall plant health among the compost-treated groups and the control group.
10- Statistical Analysis: Perform statistical tests using SPSS and R softwares to determine if any observed differences are statistically significant.
11- Presentation of Results: Present the data in tables, graphs, or charts for better visualization. Include a discussion of the implications of the findings.
12- Conclusion: Draw conclusions based on your data analysis regarding the effects of different compost types on radish seeds. Discuss any practical implications and potential recommendations for using specific compost types in gardening or agriculture.
13- Reporting: Document your findings in a research report or paper, including your methodology, results, and discussion.

Remember to maintain consistency in all aspects of the experiment except for the type of compost used to ensure that any observed differences are attributed to the compost type.

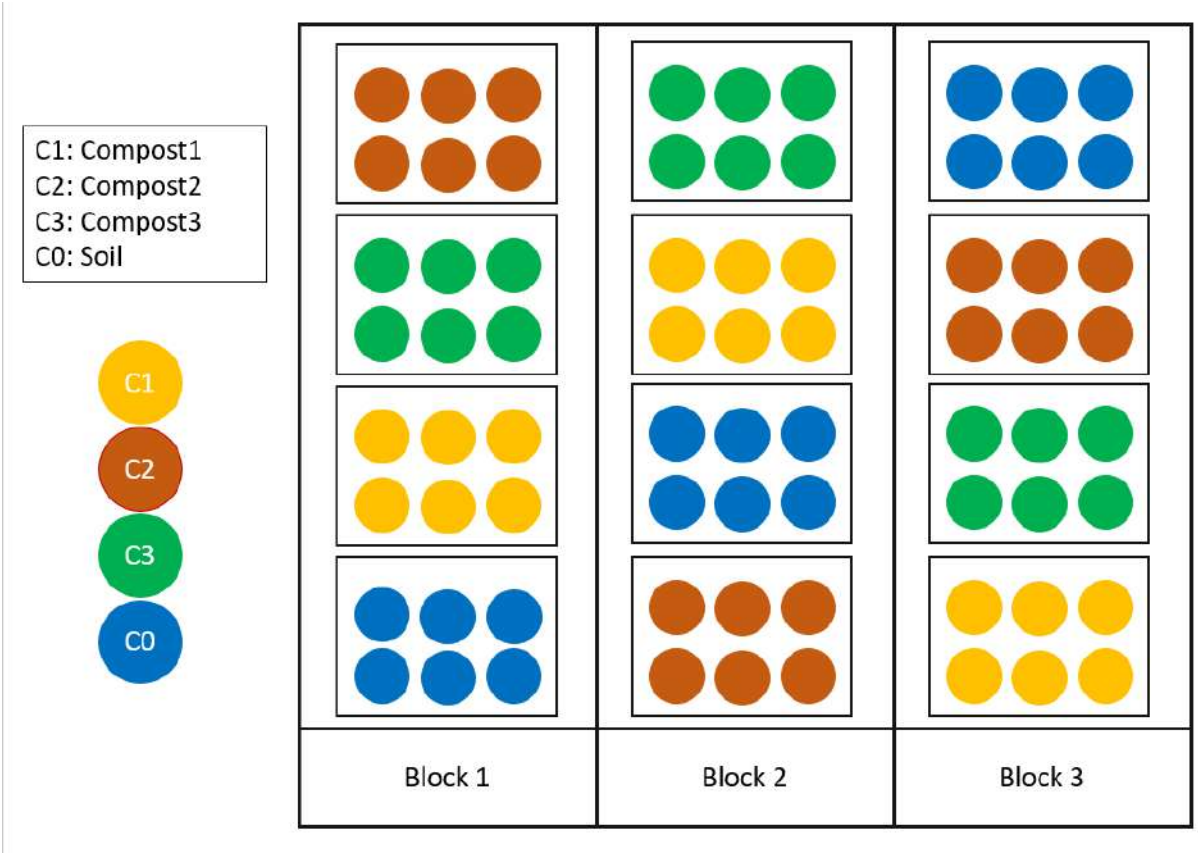
Experimental Design

- A common experimental design for this type of experiment is a randomized complete block design (RCBD). In an RCBD, the treatments are randomized within each block. This helps to reduce the effects of any variation between blocks, such as sunlight for example.

- Experimental design: Randomized complete block design (RCBD)

- Treatments:
  Control (no compost)
  Compost type 1: C1
  Compost type 2: C2
  Compost type 3: C3

- Replications: 3



Protocol 7: The Impact of Different Composts on Seed's Germination and Growth (Radish seeds)

Protocol

- **Title**: Assessing the Impact of Different Compost Types on the Germination and Growth of Radish Seeds

- Objective: To determine how different compost types affect the germination rate, seedling growth, and overall development of radish seeds

- **Duration**: 40-70 days

- **Variables**:

- Independent variable: Types of vegetables compost produced in Al Safir Orchard (3 types)
- Dependent variables: Seed germination rate, plant height, number of leaves, weed incidence, leaf length.

- **Materials**:

1. Radish seeds (F1 hybrid) = 360 seeds
2. Different types of compost (the 3 types of seed composts produced at Al Safir orchard)
3. Planting pots (72 pot)
4. A marked stick to ensure all seeds are planted at similar depth.
5. Potting soil or garden soil (control group)
6. Labels and markers (waterproof)
7. Spray bottle
8. Ruler or measuring tape
9. Light source (e.g., natural sunlight or grow lights)
10. Timer to establish a regular watering schedule, and keep track of time of data collection
11. Data recording sheet (excel sheet) or notebook

- **Experimental Setup**:

1- Preparation of Compost:
   - Obtain three different types of compost (C1, C2, and C3).
   - Ensure that each type of compost is thoroughly decomposed and ready for use.

- Composts should be screened for large debris and uniform in texture, to remove unfinished materials and minimize the incidence of weed seeds, ensure aeration, good water retention and nutrient distribution,

2- Seed Selection: Try using seeds of similar size and quality.
3- Experimental Groups: Divide the planting pots into groups, 18 for each compost type and a control group with potting soil (without compost). Label each group accordingly.
4- Compost Application: Apply different compost types to their respective groups following the experimental design assigned below.
5- Planting: Plant radish seeds (5 seeds) in each pot. Follow recommended planting depths for radish seeds (2-3 times its diameter). Be sure to plant the seeds at the same depth in all of the pots (you may use a ruler or a marked stick).
6- Watering: Water all groups evenly to maintain consistent soil moisture levels. Use a spray bottle to avoid disturbing the seeds. But be careful not to overwater them. The potting medium should be moist, but not soggy.
7- Place all pots in a location where they receive the same amount of light (natural sunlight or under grow lights).
8- Maintain consistent temperature conditions throughout the experiment.
9- Data Collection:
    - Record the following parameters regularly throughout the experiment.
    - During the experimentation, six plants under each treatment combination (from the three blocks) were randomly selected and tagged for recording the observation on growth and yield characters (whenever required). Do not remove any part of these plant before the end of the experiment.
    - Record the date when the seeds were planted (Day 0).
    - On a data recording sheet, create a table or list where you can record the data collected. Label each measurement with a unique identifier.

a. Days taken to germination: After sowing, each plot was regularly watched to record the number of days taken for full germination
b. Plant height: Height of the six **tagged** plants from each treatment were recorded from ground level to the tip of apical buds at last picking stage and then averaged to get mean heights.
c. Plant vigor: The vigor of the seedlings was determined by following the formula of Abdul-Baki and Anderson (1973). Vigor index = [mean of root length (cm) + mean of shoot length (cm)] × percentage of seed germinations. (40-70 day/ at the end of the experiment)
d. Leaf Count: Count the number of leaves on each seedling to assess the development of the radish plants over time.
e. Root Development: Carefully uproot a few seedlings from each compost type at specific intervals to examine root development. This can provide insights into the health and vigor of the radish plants.

f. Yield per plant: At time of maturity and harvest (40-70 days), measure the yield of radishes produced by each compost type. This is particularly relevant if you are interested in the practical implications for crop production
g. Incidence of weed: State whether for each type of compost there is weed emergence. If yes, try counting the number of seedlings from 6 pots for each treatment.
h. Disease Incidence: Monitor the seedlings for any signs of diseases or pests, and record whether certain composts seem to affect the susceptibility of the plants to these issues.
i. Visual Observations: Make qualitative observations about the overall health and appearance of the radish plants, including color, size, and any abnormalities.

9- Data Analysis: After an appropriate growth period (e.g., several weeks), analyze the data collected, looking for differences in germination rates, seedling growth, and overall plant health among the compost-treated groups and the control group.
10- Statistical Analysis: Perform statistical tests using R and SPSS softwares to determine if any observed differences are statistically significant.
11- Presentation of Results: Present the data in tables, graphs, or charts for better visualization. Include a discussion of the implications of the findings.
12- Conclusion: Draw conclusions based on your data analysis regarding the effects of different compost types on radish seeds. Discuss any practical implications and potential recommendations for using specific compost types in gardening or agriculture.
13- Reporting: Document your findings in a research report or paper, including your methodology, results, and discussion.

Remember to maintain consistency in all aspects of the experiment except for the type of compost used to ensure that any observed differences are attributed to the compost type.

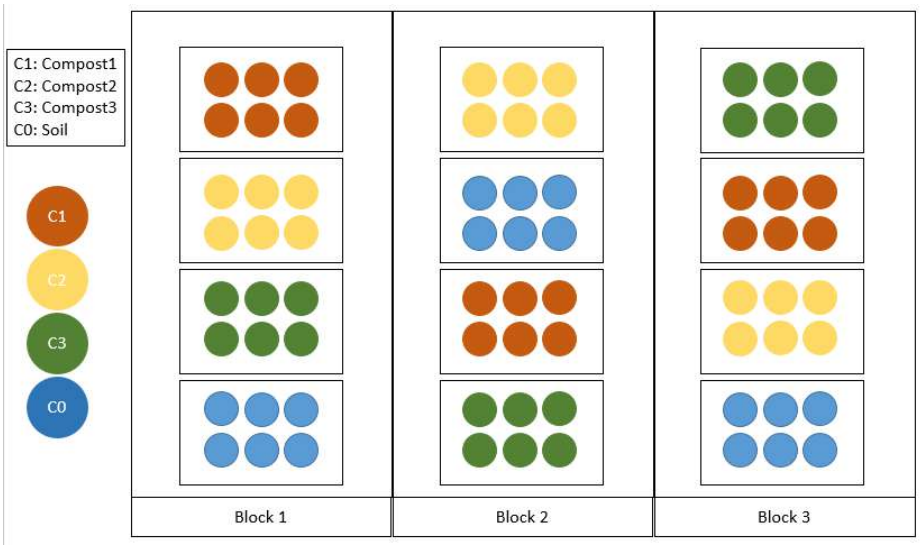
Experimental Design

- A common experimental design for this type of experiment is a randomized complete block design (RCBD). In an RCBD, the treatments are randomized within each block. This helps to reduce the effects of any variation between blocks, such as sunlight for example.

- Experimental design: Randomized complete block design (RCBD)

- Treatments:
  Control (no compost)
  Compost type 1: C1
  Compost type 2: C2
  Compost type 3: C3

- Replications: 3



Protocol 8: The Impact of Different Composts on Seed's Germination and Growth (Green Peas)

Objective: Design a protocol to measure the effect of compost application on seeds

Choice of seeds:

1- Variety

- Lettuce: is considered a good choice for the following reasons:
  a. Cool-Season Crop: Lettuce is a cool-season crop that thrives in cooler temperatures, typically between 7°C and 24°C. This makes it ideal for studying compost effects during the cool months of the year.
  b. Quick Growth: Lettuce has a relatively short growing season, and you can observe the effects of compost on growth and yield within a few weeks to a couple of months.
  c. Widespread Cultivation: Lettuce is a popular and widely grown vegetable in many regions, which means that you can find plenty of resources and literature for comparison.
  d. Sensitive to Soil Conditions: Lettuce is somewhat sensitive to soil quality, making it a good indicator of how compost affects soil fertility, nutrient content, and water retention.
  e. Visual Changes: Changes in lettuce growth and appearance can be easily observed, making it a practical choice for demonstrating the impact of compost on plant health.
- Green peas: is considered a good choice for the following reasons:
  a. Cool-Season Crop: Green peas are a cool-season crop, well-suited for autumn planting. They thrive in cooler temperatures and can tolerate light frost, making them an ideal choice for autumn experiments.
  b. Quick Growth: Green peas have a relatively short growing season, typically around 60-70 days from planting to harvest. This rapid growth allows researchers to observe the effects of compost on plant growth and development in a relatively short period. It's especially useful for short-term experiments or educational purposes.
  c. High Sensitivity to Soil Amendments: Peas are sensitive to changes in soil conditions and are responsive to nutrient availability. This makes them a good choice for studying the impact of compost on nutrient uptake, as you can often see noticeable differences in growth and yield with varying levels of compost.
  d. Legume Nitrogen Fixation: Peas are legumes, which means they have a unique ability to fix atmospheric nitrogen through a symbiotic relationship with nitrogen-fixing bacteria in their root nodules. This makes them a suitable choice for studying how compost affects nitrogen cycling and whether compost supplementation influences nitrogen fixation.

e. Versatility: Green peas are versatile and can be grown in various soil types and climates. This adaptability allows researchers to conduct studies in different regions and under different conditions, making their findings more applicable to a wider range of agricultural settings.
f. Taste and Consumption: green peas are a popular and palatable choice. So I can assess not only yield but also taste and overall quality.
g. Clear Growth Stages: Green peas have distinct growth stages that are easily observable, including germination, vegetative growth, flowering, pod formation, and harvesting. These stages make it easy to track and document changes in plant development as influenced by compost.
h. Above-Ground Growth: Green peas grow above ground, making it convenient to monitor their growth, assess leaf color, measure plant height, count flowers and pods, and observe any visual differences in response to compost application.
i. Ease of Observation: Pea plants are relatively easy to observe, and their growth stages are distinct. This makes it straightforward to monitor plant development and collect data on parameters like plant height, leaf area, flower and pod formation, and yield.

- Radish: is considered a good choice for the following reasons:
  a. Cool-Season Crop: Radishes are a cool-season crop that thrives in cooler temperatures. They are well-suited for autumn growing conditions when the weather is cooler, and many other warm-season crops are no longer suitable for planting.
  b. Quick Growth: Radishes have a relatively short growing season, typically maturing in about 20-30 days. This rapid growth allows you to conduct experiments and observe the effects of compost relatively quickly. In autumn, when temperatures are cooler and daylight hours are shorter, having a crop that matures quickly is advantageous.
  b. Ease of Cultivation: Radishes are generally easy to grow and are often recommended for beginner gardeners. They don't require complex care or maintenance, making them a practical choice for research projects.
  c. Root Development: Since radishes are primarily grown for their roots, they are an excellent choice for studying the effects of compost on root development, size, and quality.
  d. Variability in Responses: Radishes can exhibit varying responses to changes in soil quality and amendments like compost. This variability allows to detect subtle differences in plant growth and root development.
  e. Cost-Effective: Radish seeds are typically inexpensive, which makes them a cost-effective choice for conducting experiments.

2- Type: F1 or hybrid

Based on my research, I found that to choose between F1 hybrid seeds and local seeds for a compost experiment is quite difficult. Both types of seeds have their advantages and potential drawbacks. While **F1 Hybrid Seeds** tend to produce plants

that are more uniform in terms of growth, size, and maturity. This uniformity can be advantageous in scientific experiments because it reduces variability due to genetic factors. They have known genetic backgrounds, which means you can have a better understanding of the expected traits and performance of the plants. This can be important for controlling variables in my experiment and can make it easier to study the effects of compost without the interference of other genetic factors. Whereas, **local Seeds** are adapted to the specific environmental conditions of the region. Using local seeds can provide insights into how compost affects plants that have evolved to thrive in our local climate and soil. They can also help preserve biodiversity by supporting local plant varieties.

Moreover, based on a study carried by Yan Yang and his colleagues where they were testing the maturity of compost, the seed germination index that is widely used as an indicator of compost maturity was best characterized by hybrid cucumber seeds rather than the other 16 local vegetables seeds (Yan et al., 2021). Which thus can be considered as a sensitive and reliable seed suitable for evaluation of compost efficiency.

Since, I want to study the effects of compost on specific, predictable traits and reduce genetic variability in my experiment, I think **F1 hybrid seeds** may be a suitable choice. **F1 hybrid seeds produce plants that are genetically uniform, meaning they have consistent growth patterns and responses to environmental conditions. This consistency and uniformity reduces genetic variability among the plants, making it easier to attribute any observed differences in plant growth or performance to the effects of our compost rather than genetic variations.**

Life Cycle of Green Peas

Day 1-10: Germination
- After planting seeds in well-prepared soil, pea seeds will germinate within about 7-10 days, depending on soil temperature and moisture levels.
- During this stage, the seedlings develop roots and the first true leaves begin to emerge.

Day 10-20: Seedling Stage
- The seedlings continue to grow, and the first true leaves become more prominent.
- Pea plants at this stage require consistent moisture and protection from pests and diseases.

Day 20-30: Vegetative Growth
- The pea plants enter the vegetative growth stage, where they focus on producing foliage and establishing a strong root system.

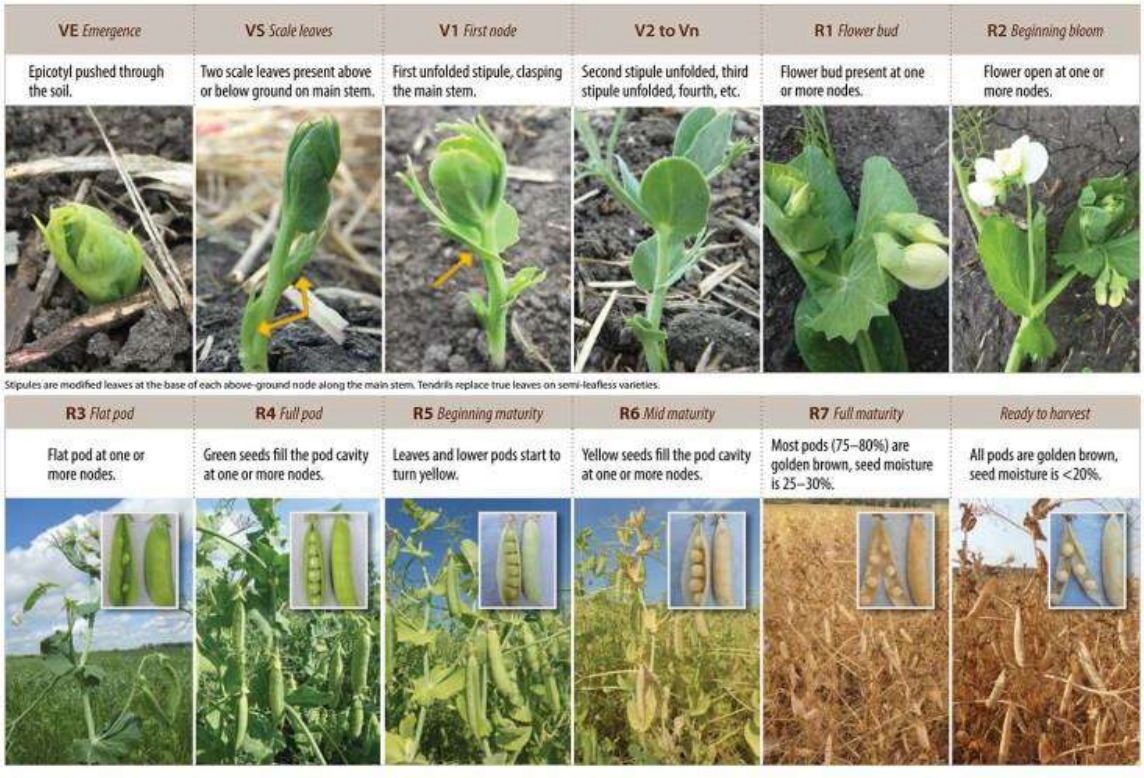
- They require regular watering and should be kept free from weeds that can compete for nutrients.
- Pea tendrils start to form, which help the plant climb and support itself.

Day 30-40: Flowering
- Pea plants typically start flowering around day 30-40 after planting, although this can vary by variety and environmental conditions.
- During this stage, the plants produce white or pinkish flowers that are self-pollinating but can also be pollinated by insects.

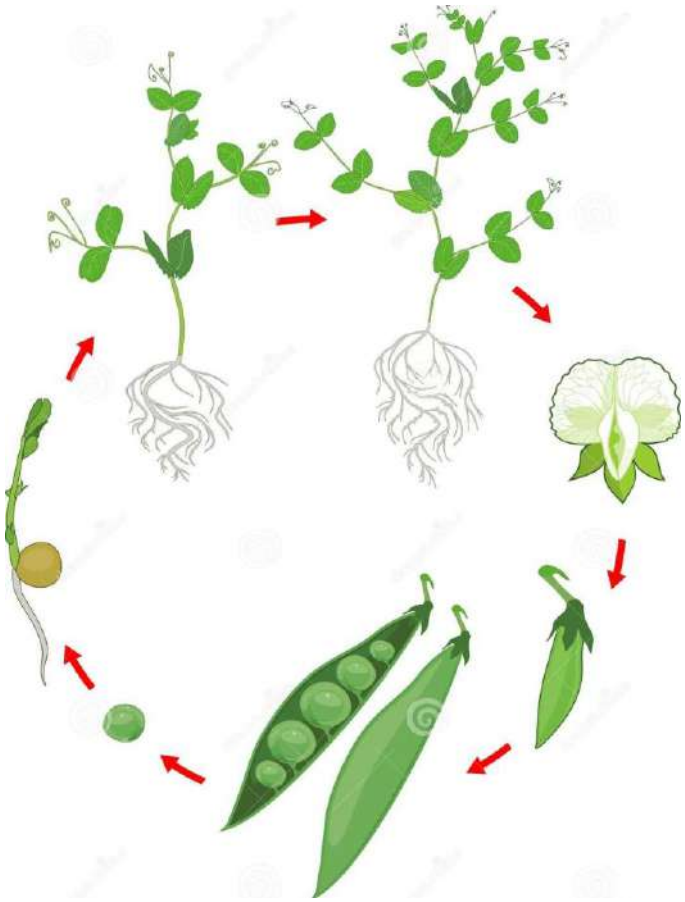
Day 40-65: Pod Development
- As the flowers are pollinated, they transform into pea pods.
- Pea pods will continue to grow and fill out during this stage, and the plant's energy shifts from vegetative growth to pod production.
- Adequate moisture is essential for pod development.

Day 65-80: Harvest
- The time to harvest peas depends on the desired stage of maturity. Young, tender peas are harvested earlier, while mature peas for drying are left on the plant longer than 80 days.

It's important to note that these timeframes are approximate and can vary based on the specific pea variety, local climate conditions, and cultural practices. Regular monitoring and adjusting care practices accordingly will help ensure a successful pea harvest in Lebanon during the fall season.



Field Pea Growth Staging Guide/ Resource: https://www.manitobapulse.ca/2018/10/field-



Protocol

- **Title**: Assessing the Impact of Different Compost Types on the Germination and Growth of Green Pea Seeds

- **Objective**: To determine how different compost types affect the germination rate, seedling growth, and overall development of green pea seeds.

- **Duration**: 50-80 days

- **Variables**:

- Independent variable: Types of vegetables compost produced in Al Safir Orchard (3 types)
- Dependent variables: Seed germination rate, plant height, number of pods, number of seeds in pods, weigh of 100 seeds, plant biomass,…

- **Materials**:

1. Green pea seeds (F1 hybrid) = 250 seeds (in the market a 100 seeds average weight is between 25-30g, one seed weigh 0.25-0.3g, so in total I need **63- 75g** of green pea seeds)

2. Different types of compost (the 3 types of seed composts produced at Al Safir orchard)
3. Planting pots (72 pot)
4. A marked stick to ensure all seeds are planted at similar depth.
5. Potting soil or garden soil (control group)
6. Rope or rafia to raise the plants
7. Labels and markers (waterproof)
8. Spray bottle
9. Ruler or measuring tape
10. Light source (e.g., natural sunlight or grow lights)
11. Timer to establish a regular watering schedule, and keep track of time of data collection
12. Data recording sheet (excel sheet) or notebook

- **Experimental Setup:**

1- Preparation of Compost:
   - Obtain three different types of compost (C1, C2).
   - Ensure that each type of compost is thoroughly decomposed and ready for use.
   - Composts should be screened for large debris and uniform in texture, to remove unfinished materials and minimize the incidence of weed seeds, ensure aeration, good water retention and nutrient distribution,

2- Seed Selection: Try using seeds of similar size and quality.

3- Experimental Groups: Divide the planting pots into groups, 12 for each compost type and a control group with potting soil (without compost). Label each group accordingly.

4- Compost Application: Apply different compost types to their respective groups following the experimental design assigned below.

5- Planting: Plant green pea seeds (2-3 seeds) in each pot. Follow recommended planting depths for your specific green pea variety (2-3 times its diameter). Be sure to plant the seeds at the same depth in all of the pots (you may use a ruler or a marked sticks).

6- Watering: Water all groups evenly to maintain consistent soil moisture levels. Use a spray bottle to avoid disturbing the seeds. But be careful not to overwater them. The potting medium should be moist, but not soggy.

7- Place all pots in a location where they receive the same amount of light (natural sunlight or under grow lights).

8- Maintain consistent temperature conditions throughout the experiment.

9- Data Collection:
   - Record the following parameters regularly throughout the experiment.
   - During the experimentation, six plants under each treatment combination (from the three blocks) were randomly selected and tagged for recording the

observation on growth and yield characters (whenever required). Do not remove any part of these plant before the end of the experiment.

- Record the date when the seeds were planted (Day 0).
- On a data recording sheet, create a table or list where you can record the data collected. Label each measurement with a unique identifier.

a. Germination rate: Green peas seeds need usually between (1-10 days) to germinate. So, keep monitoring the containers daily, and record the number of germinated seeds daily. After the monitoring period is complete, calculate the germination rate using the following formula:
Germination Rate (%) = (Number of Germinated Seeds / Total Number of Seeds Planted) x 100
b. Number of nodules per plant: Six plants (**not tagged**) were randomly uprooted carefully along with soil from each treatment at flower bud initiation (30-40 days). The roots of plants were dipped in water for some time to facilitate the removal of soil from the roots without damage. The number of nodules present on the roots counted under each treatment and then averaged. The nodules of Six plants under each treatment were carefully removed with the help of forceps. Weighted on the electronic top loading balance for getting their accurate fresh weighs and finally averaged. Freshly weighted nodules from Six plants were put in oven for drying at 600 C for 72 hrs. The nodules were again weighted on electronic top loading balance and averaged.
c. Plant height: Height of the six **tagged** plants from each treatment were recorded from ground level to the tip of apical buds at last picking stage and then averaged to get mean heights. Measure and record the height of each green pea plant at regular intervals (every 10 days) until the end of the experiment. Plant height was measured every 10 days for one plant per plot, with a total of six plants per treatment. A minimum of 8 measurements should be done. **Make sure to measure the height of the same plants every 10 days.**
d. Pod length: Choose green pea pods that are mature and ready for harvesting (65-80 day). Choose one pod from each 6 **untagged** plant. Using a ruler or measuring tape, measure the length of the green pea pod from the base (where it was attached to the plant) to the tip.
e. Plant vigor: The vigor of the seedlings was determined by following the formula of Abdul-Baki and Anderson (1973). Vigor index = [mean of root length (cm) + mean of shoot length (cm)] × percentage of seed germinations. (65-80 day/ at the end of the experiment)
f. Plant morphology: Monitor and record any visible differences in plant health, leaf color, and overall growth.
g. Days taken to first flowering: Days taken for appearance of first flower from the date of sowing were recorded on six randomly selected plants under each treatment. Then average days required for flowering were calculated. (starting from 4-6 weeks or 30-40 days)

a. Number of pods per plant: this is determined at harvest stage (65-80 days) from 6 **tagged** plants for each treatment.
b. Number of grains per pod: Choose 6 matured pods from **untagged** plants for each treatment and count the number of grains in each pod at maturity (65-80 days).
c. Yield per plant: At time of maturity and harvest (65-80 days), count the number of pods produced on each **tagged** plant (6 for each treatment), collect all the pods from each plant, and record the number of pods per plant and the weight of the pods (in grams) for each plant.
d. Incidence of weed: State whether for each type of compost there is weed emergence. If yes, try counting the number of seedlings from 6 pots for each treatment.

9- Data Analysis: After an appropriate growth period (e.g., several weeks), analyze the data collected, looking for differences in germination rates, seedling growth, and overall plant health among the compost-treated groups and the control group.
10- Statistical Analysis: Perform statistical tests using R software to determine if any observed differences are statistically significant.
11- Presentation of Results: Present the data in tables, graphs, or charts for better visualization. Include a discussion of the implications of the findings.
12- Conclusion: Draw conclusions based on your data analysis regarding the effects of different compost types on green pea seeds. Discuss any practical implications and potential recommendations for using specific compost types in gardening or agriculture.
13- Reporting: Document your findings in a research report or paper, including your methodology, results, and discussion.

Remember to maintain consistency in all aspects of the experiment except for the type of compost used to ensure that any observed differences are attributed to the compost type.

Experimental Design

- A common experimental design for this type of experiment is a randomized complete block design (RCBD). In an RCBD, the treatments are randomized within each block. This helps to reduce the effects of any variation between blocks, such as sunlight for example.

- Experimental design: Randomized complete block design (RCBD)

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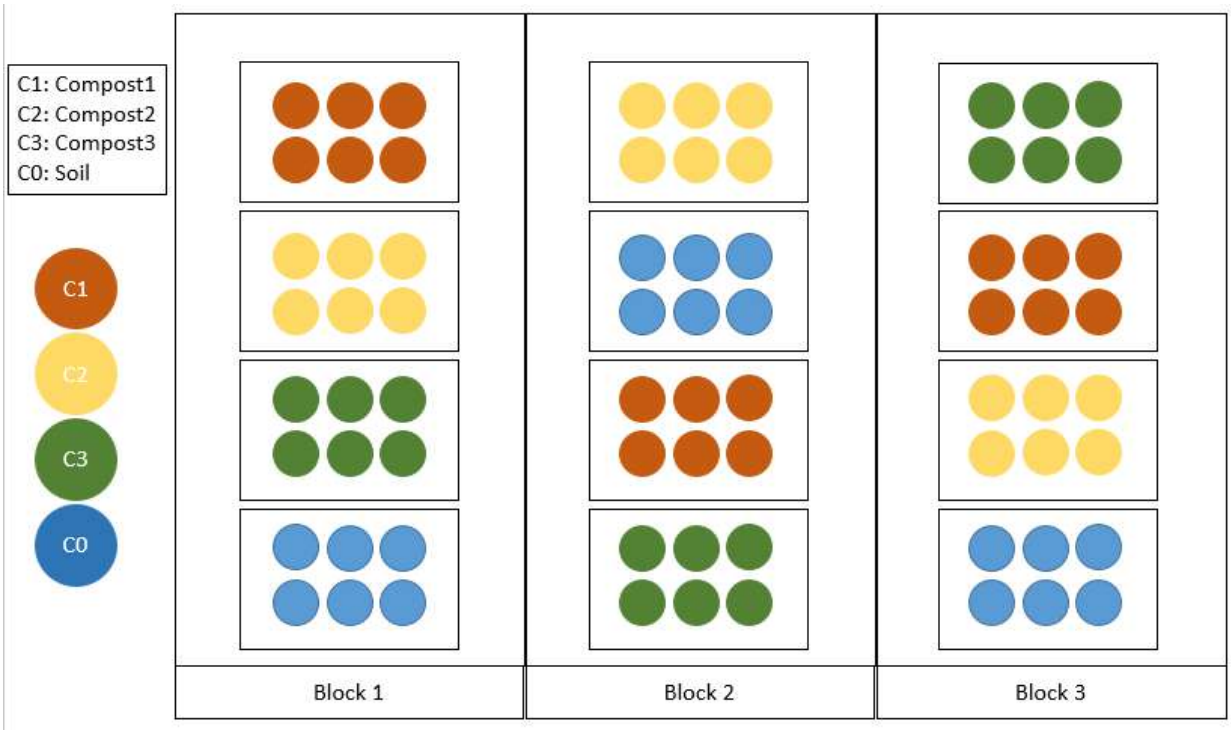

References

Yang, Y., Wang, G., Li, G., Ma, R., Kong, Y., & Yuan, J. (2021). Selection of sensitive seeds for evaluation of compost maturity with the seed germination index. *Waste management*, *136*, 238-243.