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Soil Characteristics and Their Effect On the Quality of the Fruits of the Saudi Palm Plant

by

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Content Table

Research Title:

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Key Terminologies:

The date palm plant is a dioecious tree: the male sex on one tree and the female sex on another tree.
Kingdom: plants.
Division: covered with seeds.
Class: monocotyledonous.
Order: Fofoliaceae.
Subfamily: Areca.
Gender: Phoenix.
Scientific name: *Phoenix dactylifera*.
Dates fruit: The fruit of the palm tree takes several colors, including yellow and red, and its color may change after it is fully ripe, becoming brown or black. It has a sweet taste. The length of the balah varies from 2.5 cm to 7.5 cm. Dates are eaten either wet or dry. Palm trees vary in annual production, as the production ranges from 100 kilograms to 400 kilograms, based on the quality of the soil, the abundance of water, and the plant's absence of diseases.

Abstract:

This research explores the influence of soil characteristics on the quality of Saudi date palm fruits within the context of Al-Zulfi City, Saudi Arabia. It addresses the impact of soil acidity, salinity, and conductivity on date palm growth, aiming to ascertain the correlation between soil properties and fruit quality. The primary research question focuses on how variations in soil characteristics affect the growth and quality of date palm fruits.

The research objectives revolve around comparing soil properties in two distinct areas (Area 1 and Area 2) with identical water sources but differing soil types. It investigates the resultant effects on date palm fruit quality, emphasizing observations during the fruit ripening stage in August.

Findings indicate a direct relationship between soil pH levels and fruit quality. Site 2, characterized by a higher pH (9.1), exhibited smaller-sized and more wrinkled dates (6.9 cm diameter) than Site 1 with better soil conditions, resulting in larger and less wrinkled dates.

Recommendations emphasize the significance of farmers' awareness regarding soil characteristics before planting, advocating for suitable soil care practices. This includes appropriate fertilizer application, irrigation strategies, plant selection, and consulting agricultural offices for soil analysis to optimize crop production.

In conclusion, the research underscores the pivotal role of soil properties, particularly acidity, in determining date palm fruit quality. Educating farmers about soil attributes is imperative to modify soil conditions for enhanced crop yield.

Keywords: Soil Characteristics, Date Palm, Fruit Quality, Soil pH, Farmer Education.

Introduction:

The Kingdom of Saudi Arabia's Al-Zulfi City is a well-known date palm (Phoenix dactylifera) cultivation center. The region's dry climate and scarce water supplies present opportunities as well as challenges for agricultural practices (Aleid, S. M., Al-Khayri et al., 2015). Date palms are important to the socioeconomic structure of the area because they are a major source of income and nutrition for many families, both domestically and abroad (Jain, S. M., & Johnson, D. V, 2015).

The properties of the predominant soil in the area significantly impact the growth and quality of date palm fruits. Date palm plants' nutrient availability, root absorption, and overall production are significantly impacted by soil characteristics like pH, salinity, and conductivity (Adhikari & Notaguchi, 2022). The vigor, fruit quality, and yield of date palms are all impacted by the important nutrients that are absorbed due to the major influence of soil qualities (Elsayd El-Merghany et al., 2018).

Research carried out in similar arid regions highlights how important it is to optimize soil conditions for sustainable agriculture. Comprehensive soil management plans tailored for date palm agriculture are necessary to ensure agricultural sustainability in such areas (Alotaibi, 2023). Effective soil management techniques must be used, particularly in light of the effects that water shortages and climate change would have on agriculture in arid regions (Naorem, A. et al., 2023).

Literature review:

The scientific literature has thoroughly examined the connection between crop productivity and soil properties. Adhikari & Notaguchi (2022) investigated how date palm trees absorb nutrients about the pH of the soil. Their study clarified the relationship between pH fluctuations in the soil and the absorption of nutrients, highlighting the importance of preserving ideal pH levels to guarantee healthy growth circumstances for date palms.

Like this, Almadini et al. (2021) carried out a thorough investigation of soil management techniques relevant to the sustainable growth of date palms. Their conclusions highlighted how important it is to implement effective soil management techniques to maintain agricultural practices in arid climates and increase crop output.

Furthermore, Naorem, A. et al. (2023) clarified the difficult obstacles that drought circumstances in desert places present. Their research made clear how important it is to develop mitigation plans that work, highlighting the critical role that soil management plays in helping us adjust to the changing natural world.

To get more insight into the relationship between crop output and soil characteristics, Al-Dakheel et al. (2022) carried out a study examining the effect of soil salinity on date palm productivity. Their study highlighted the negative impacts of high salt content on plant health and yield by showing a clear link between higher soil salinity and decreased growth metrics in date palm trees.

Additionally, Aleid, S. M., and Al-Khayri et al. (2015) looked into how soil conductivity affected the growing of date palms in arid areas. Their research revealed a strong correlation between soil conductivity levels and date palm tree productivity and general health. Increased soil conductivity hurt nutrient availability and root absorption, which jeopardized date palm fruit quality and growth.

On the other hand, Dhaouadi et al. (2021) noted how better soil management techniques affected the growing of date palms. Their research showed that specific soil amendments and irrigation methods improved soil quality, which in turn boosted date palm growth metrics and fruit yield.

Moreover, Ghouili et al. (2023) studied soil nutrient management for date palm production in light of the possible effects of soil health on sustainable agriculture. Their results demonstrated that to maximize date palm growth and fruit quality while maintaining long-term soil fertility, a balanced soil nutrient composition and proper fertilizer application are essential.

All these studies point to the importance of soil properties, such as conductivity, pH, and salinity, in determining the viability and sustainability of date palm farming in arid climates. Comprehending and proficiently handling the characteristics of soil are essential for cultivating strong farming methods and guaranteeing steady production in date palm cultivation.

Research Problem:

Due to its economic importance and cultural legacy, date palm planting is an essential agricultural practice in Al-Zulfi City, Saudi Arabia. However, a major obstacle to achieving the best crop yield and fruit quality is the cultivation's numerous problems, which are rooted in the quality of the soil. Understanding the complex interactions between soil properties and environmental factors and how they directly affect date palm growth, health, and fruit output is where the difficulty lies.

Al-Zulfi City's dry climate makes soil-related problems worse and causes fluctuations in soil properties like conductivity, pH, and salt. These differences have a substantial impact on the physiological functions of date palm trees, influencing their capacity to absorb nutrients, control the amount of water they take in, and eventually affect the development and quality of their fruit. To minimize potential agricultural problems and maximize crop yield, a thorough investigation of the complex interaction between soil properties and date palm growth is necessary.

Furthermore, a sophisticated knowledge of soil characteristics and how they affect date palm agriculture is essential for sustainable agricultural methods in arid environments. Maintaining soil health and creating the ideal environment for healthy date palm development requires soil management techniques that are specifically designed to address issues with conductivity, acidity, and salinity levels.

Deciphering the subtle intricacies of soil features and their direct implications for date palm farming in Al-Zulfi City, thus, constitutes the research challenge. It is essential to address these issues empirically to develop well-informed policies that are intended to improve crop resilience, optimize soil conditions, and maintain agricultural productivity in arid areas.

Research Questions:

How directly do the properties of the soil, especially fluctuations in pH, salinity, and conductivity, affect the quality of the growth and fruit output of date palms in Al-Zulfi City, Saudi Arabia؟

The research aims to address the following set of related questions through the preceding core question:

1. How do different soil pH levels impact Al-Zulfi City's date palm trees' capacity to absorb water and nutrients?
2. How specifically do variations in soil salinity affect the development habits and physiological well-being of date palm plants in the area?
3. How does soil conductivity affect date palm fruit development, size, and general quality in Al-Zulfi City's arid climate?
4. How do differences in date palm productivity and fruit quality relate to the interplay of soil characteristics, including pH, salinity, and conductivity?
5. To minimize the negative effects of the soil features on date palm farming and maximize crop output in Al-Zulfi City, what are the best soil management practices that can be used?

Research Hypotheses:

1. Hypothesis 1: Date palm fruit quality and soil characteristics

- Null Hypothesis (H_0): The quality features of date palm fruits in Al-Zulfi City are not significantly correlated with the properties of the soil (pH, salinity, and conductivity).
- Hypothesis Alternative (H_1): Date palm fruit quality is greatly impacted by variations in soil properties, especially conductivity, pH, and salt, which in turn affects the fruit's size, look, and market value.

2. Hypothesis 2: Growth Parameters for Date Palms and Soil Features

- Null Hypothesis (H_0): The growth parameters of date palm trees in the researched region are not significantly influenced by soil characteristics, such as pH, salinity, and conductivity.
- Alternative Hypothesis (H_1): Differences in soil characteristics have a direct impact on date palm growth metrics, including height, leaf health, and general vigor, which in turn affects the date palm trees' overall growth and development.

3. **Hypothesis 3: Crop Yield Optimization and Soil Management Techniques**
   - Null Hypothesis (H_0): Optimising crop output and quality for date palm farming in Al-Zulfi City is not significantly impacted by standard soil management techniques.
   - Alternative Hypothesis (H_1): Date palm crop production, fruit quality, and overall agricultural productivity are effectively increased by the application of customized soil management practices that consider soil characteristics.
4. **Hypothesis 4: How Soil Attributes Interact to Affect Date Palm Productivity**
   - Null Hypothesis (H_0): The region's date palm production is not significantly influenced by the interaction of soil properties (pH, salinity, and conductivity).
   - Alternative Hypothesis (H_1): In Al-Zulfi City, date palm productivity, fruit development, and total crop production are strongly impacted by the interaction between soil parameters and their combined effects.

Importance of the Research :

1. **Agricultural Sustainability in Arid Saudi Environments:** Al-Zulfi City, which is in the Kingdom of Saudi Arabia, has problems with dryness and poor soil, which are especially important for maintaining farming activities. Maintaining sustainable agricultural production in the area requires an understanding of the relationships between date palm farming and soil characteristics.
2. **Enhancing the Kingdom's Date Palm Industry:** In Saudi Arabia, date palm agriculture is very important economically. The Kingdom's date palm business can be impacted by improving soil conditions through educated methods since it will increase crop yields, guarantee higher-quality produce, and improve the financial prospects of nearby farmers.
3. **Empowering Local Farmers and Stakeholders:** Giving local farmers and other agricultural stakeholders access to information on optimum soil management techniques suited to Al-Zulfi City's particular soil characteristics empowers them. With this information at hand, people may contribute to the local economy by enhancing crop productivity, putting ideas into action, and making well-informed decisions.

4. **Supporting Saudi Arabia's Agricultural Innovation:** Through exploring the complex relationship between date palm growth and soil properties, the research advances agricultural innovation in the Kingdom. It supports the Kingdom's goals for technological improvements and sustainable agricultural practices by offering a basis for the advancement of agricultural techniques.
5. **Cultural and Economic Significance:** Saudi Arabian date palms are culturally significant since they are ingrained in the country's history and customs. By guaranteeing the continued growth of this important commodity, date palm farming optimized through enhanced soil management helps both economic prosperity and cultural heritage preservation.
6. **Informing Saudi Agricultural Policy and Practices:** The research's conclusions can help Saudi Arabia's agriculture practices and policies. Policymakers, researchers, and agricultural authorities can be guided in developing policies and practices that support sustainable and productive agriculture in the Kingdom by using data-driven advice on soil management measures.

Research Objectives:

1. To Examine the Effect of Soil Features: o Examine the effects of conductivity, pH, and salinity on the growth parameters and fruit quality of date palm trees in Al-Zulfi City.
2. To Evaluate Soil-Related Effects on Date Palm Development: o Determine the precise impacts of different soil properties on date palm development in the chosen areas, including height, leaf health, and general vigor.
3. To ascertain the best soil management techniques:
   - Determine and suggest customized soil management techniques that maximize soil properties for date palm growth to raise crop output and enhance fruit quality.
4. To Examine the Effects of Soil on Productivity:
   - Examine the relationships between various soil characteristics and how they affect crop production, fruit development, and date palm productivity when taken together.
5. To Offer Guidelines for Agricultural Procedures:
   - Create data-driven recommendations that farmers, agricultural officials, and legislators may use to put into practice efficient soil management techniques that support the sustainable growth of date palms in Al-Zulfi City.

Research Terms:

1. Date Palm (Phoenix dactylifera): A species that is widely planted in desert areas like Al-Zulfi City, Saudi Arabia, for its fruit, dates, is widely cultivated (Jain, S. M., & Johnson, D. V, 2015).

2. Soil pH: The amount of acidity or alkalinity in the soil that affects the availability of nutrients and the uptake of those nutrients by the roots in date palm farming (Adhikari & Notaguchi, 2022).

3. Soil Salinity: The amount of soluble salts in the soil that affects date palm trees' ability to absorb water and maintain their ion balance. Plant development and production may be adversely affected by elevated soil salt levels (Rengasamy, 2016).

4. Soil Conductivity: The capacity of soil to conduct electrical currents, a measure of salinity that influences plant health and nutrient availability (Bidalia, et al., 2019).

5. GLOBE Program: An international science and education program that offers methods for soil and water analysis and supports environmental research for educators and students (GLOBE Implementation Office, 2021).

6. Agricultural Sustainability: the process of sustaining agricultural output while protecting the environment and making sure farming methods are profitable (Naorem, A. et al., 2023).

7. Optimized Soil Management: customized plans that take conductivity, pH, and salinity into account to maximize the growth and quality of date palm crops (Elsayd El-Merghanyet al., 2018).

8. Arid Environments: Low precipitation, high evaporation rates, and scarce water resources are characteristics of these regions that affect crop cultivation and agricultural methods (Alotaibi, 2023).

Methodology:

The approach used in this study aims to clarify the complex relationship that exists between the growth quality of Saudi date palm fruits in the Al-Zulfi region and the features of the soil. This study uses a methodical strategy to combine various approaches for analyzing soil properties, tracking plant development, and evaluating fruit quality. The process of gathering, analyzing, and drawing conclusions based on accepted practices and frameworks in agricultural research is all included in the research methodology.

Using a multifaceted approach, the study technique integrates Globe methods for water assessment, land cover observation, and soil analysis. The research is based on a comparative analysis that compares two different regions in Al-Zulfi City that have different soil conditions and, as a result, affect the growth and quality of the fruit produced by date palms.

By monitoring soil characteristics including pH, salinity, and conductivity in both locations, date palm production can be estimated by applying Globe procedures to soil analysis. Simultaneously, date palm growth and fruit quality can be examined more easily by utilizing land cover observation techniques. This allows for the evaluation of differences in size, shape, and skin texture between the research locations. Furthermore, the protocols for water evaluation seek to evaluate the water supply that is utilized for soil irrigation to comprehend its impact on soil characteristics and the growth of plants.

Research Sample:

Two discrete regions of Al-Zulfi City were selected for comparative examination in this study. The research locations are Areas 1 and 2, which are exposed to comparable environmental elements including light and water amount, and share the same water supply. The soil types in the two sites are what set them apart and provide an independent variable for investigation.

Every region is home to date palm farms that contain date palm trees of the same kind and age. To assess growth metrics and fruit quality, five representative date palm plants are observed for 10 months within each farm. To minimize any differences in soil nutrient levels, the same amount of organic fertilizer is administered to the soil at both locations at different times of the year.

This methodical approach seeks to enable a thorough assessment of how different soil properties directly affect the growth and quality of the fruits produced by date palms, providing crucial information about the best ways to manage the soil to cultivate date palms sustainably.

Research Plan:

1. Data gathering (December 2022–January 2023): Start the investigation by compiling thorough data on date palm growth and soil conditions from a variety of sources, such as reputable internet resources and books in the Learning Resource Center. The goal of this stage is to create a solid knowledge foundation for the study.
2. Development of a Search Plan (January 2023): Create a methodical search strategy that outlines the main areas of inquiry, including date palm agriculture, soil properties, and agricultural practices. Describe the precise areas to look at when conducting the research.
3. Establishing the Schedule (February 2023): Establish a well-defined schedule that outlines the procedures and deadlines for implementing the research. Establish deadlines for every stage to guarantee an organized and effective research process.
4. Acceptance of Experimentation-Based Learning (February 2023–August 2023): Investigate the direct impact of soil parameters on the growth quality of Saudi palm plant fruits by utilizing experimental research approaches. Create trial configurations that allow you to closely track and evaluate the effects of soil on date palm productivity.
5. Protocol Determination (March 2023): Specify and describe the procedures that must be followed to carry out the research in an efficient manner. Determine the Globe protocols for water evaluation, land cover observation, and soil analysis to understand their impact on date palm development.
6. Identification of Tools and Equipment (April 2023): Ascertain the instruments and equipment required to carry out the research tasks. Invest in tools such as conductivity, salinity, and pH meters to monitor soil and water properties precisely.
7. Gathering and Arranging Data (May 2023 - July 2023): Collect soil and water samples, carry out experiments, and record observations to start the data collection process. For ease of analysis, arrange the gathered data in tables methodically.
8. Data Entry into Program Website (July 2023): Carefully enter the collected data into the program website, making sure the dataset is accurate and comprehensive.
9. Data Interpretation and Analysis (August 2023): Analyze the data thoroughly to extract valuable insights from the gathered data. To promote thorough understanding, communicate the data using analytical summaries and graphic representations.
10. Recommendations and Conclusions (September 2023): Provide a summary of the study's findings and conclusions based on the data analysis. Provide well-reasoned advice on the best ways to manage the soil to enhance date palm growth and fruit quality.

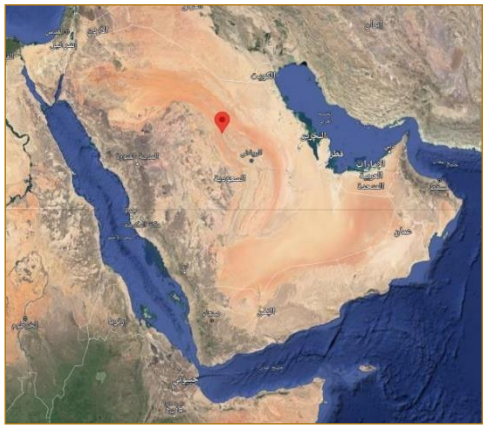
Timetable of the research plan implementation:

Name	Task	Date
Adeeb Abdullah Al-Toraiqi	Collect information on the research subject from various resources.	December 2022
Adeeb Abdullah Al-Toraiqi	Determine the two farms to which research tools will be applied.	January 2023
Adeeb Abdullah Al-Toraiqi	Collect samples of water and soil to apply different protocols.	February 2023
Adeeb Abdullah Al-Toraiqi	Interview the agricultural engineer in the Department of Agricultural Development in Zulfi.	August 2023
Adeeb Abdullah Al-Toraiqi	Observe the results and write the research paper based on the findings.	October 2023

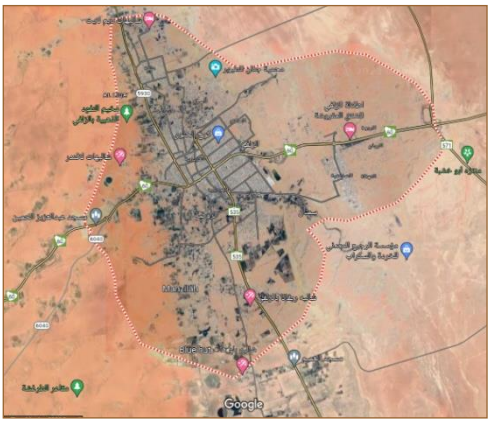
For Adeeb Abdullah Al-Toraiqi's participation in the research plan, the table effectively arranges the duties and the dates that correspond to them. It lays out important duties at various phases of the research process in a clear timeline of consecutive tasks. This methodical framework guarantees a methodical approach to the study plan by improving readability and making it easier to understand the different activities that are allocated within designated periods.

Survey Location and Climate Analysis:

The study is carried out in the Al-Zulfi Governorate, which is located in the Kingdom of Saudi Arabia's Riyadh Region. The region, which is located at Latitude 26.285643 and Longitude 44.797267, has a unique semi-arid to desert climate that has a big impact on crop development and agricultural techniques.



Kingdom of Saudi Arabia



The study site (Al-Zulfi Governorate)

Climate Overview:

The climate of the Al-Zulfi Governorate is characterized by sharp temperature swings and little precipitation. Temperatures in the winter vary from 20 to 30 degrees Celsius, with somewhat colder evenings and pleasantly warm daytime highs, which are experienced from December to February. March to May is when spring arrives, and at that time, the temperature soars to new heights, ranging from 30 to 40 degrees Celsius. The hottest months of the year are the summer months, which run from June to August. The average high is between 35 and 45 degrees Celsius. On the other hand, the fall season, which lasts from September to November, gradually cools off from the summer heat with temperatures between 25 and 35 degrees Celsius.

Water and Land Cover Protocols Utilized:

The research in the Al-Zulfi Governorate incorporates specialized protocols to comprehensively research water and land cover aspects. These protocols involve sophisticated methodologies and techniques:

1. **Water Protocol:** The evaluation of water sources used for soil irrigation is part of this methodology. It involves taking measurements of vital water parameters like conductivity, pH, and salinity. An understanding of water quality and its effects on soil characteristics and crop growth can be gained from evaluating these metrics.
2. **Land Cover Protocol:** This technique entails a thorough examination and assessment of the land cover, with an emphasis on features of agricultural landscapes, soil properties, and vegetation cover. Its objective is to assess the relationship between characteristics of land cover and how it affects crop productivity and cultivation.

A thorough and methodical examination of the relationship between environmental factors-most notably, land cover and water quality-and their effects on agricultural practices-specifically, date palm production in the Al-Zulfi region-is made possible by the application of these specialized methods.

Data collection and analysis:

The technique employed for both data collecting and analysis is extensive and multidimensional, to thoroughly address the study question. To conduct a thorough investigation of soil attributes, water quality, and palm fruit characteristics, a variety of methods and specialized technologies will be utilized.

First, a pH meter will be used in the soil procedure to accurately determine the levels of acidity in the soil. Furthermore, conductivity and salinity meters will be used to determine the salinity and conductivity of the soil. awareness of the chemical makeup of the soil and its possible effects on plant growth—particularly on the quality of date palm fruit—requires an awareness of these characteristics.

Additionally, using a ground cover protocol will make it easier to observe palm fruit quality. Using this technique, scientists will be able to evaluate and record the size, texture, and general health of the palm fruit, among other elements of its appearance. Comprehending the relationship between soil characteristics and the noted quality of the palm fruits is essential for creating associations and deriving inferences on the influence of soil features on date palm cultivation.

In addition, a water procedure will be put into place to evaluate the water supply that is utilized for land irrigation. Measurements and analyses of the water's conductivity, salinity, and acidity will be part of this technique. The qualities of the soil and, consequently, plant growth are greatly influenced by the quality of irrigation water. By looking at these aspects, scientists want to understand how the properties of the water might interact with those of the soil, influencing the general development and caliber of date palm fruits.

All things considered, the application of these many procedures and specialized equipment for soil, water, and plant evaluations shows an all-encompassing method of gathering data. With the use of this multidimensional approach, researchers will be able to compile intricate and subtle data that will support a thorough study and offer a thorough understanding of the variables affecting date palm production and fruit quality.

Methods of Data Collection:

1. **Selection of research Areas:** Based on their shared usage of a single water source, equivalent water quantities, and regular exposure to comparable lighting conditions, two separate locations were chosen for the study. The main distinction between these regions was the kind of soil, which the study treated as an independent variable. By holding other variables constant, the selection procedure sought to isolate the effect of soil differences on date palm development.

Area 1

Area 2

2. **Sampling and Analysis:** Samples of soil and water were carefully taken from the designated regions. These samples were subjected to a comprehensive examination process that measured salinity, conductivity, and acidity (pH values) using specialist Globe instruments. The accuracy of these measurements was crucial for evaluating and contrasting the soil qualities.

Prepare the materials

Read measurements

3. **Monitoring of Date Palm Plants:** Five date palms of the same age and type were closely observed in each of the two areas that were chosen. By ensuring consistency across the plant specimens under study, this phase aimed to enable a direct comparison of growth responses impacted by soil changes.
4. **Standardized Organic Fertilization:** In both test locations, the soil was uniformly treated with the same amount of organic fertilizer in December and January to preserve consistency and reduce unnecessary variables. By supporting plant growth uniformly in both locations, this standardized fertilization method attempted to provide fair conditions for date palm development.
5. **Comparison of Fruit Quality:** The quality of date palm fruit produced in the two research regions was thoroughly compared in August during the ripening stage. Date palm quality qualities were directly evaluated about soil type variations, thanks to the careful observation and assessment of factors such as fruit size and form.

Results :

The analysis of water properties, specifically the fluorescence water, utilizing GLOBE devices, reveals significant characteristics essential for understanding the environmental context. The obtained data showcases key parameters:

	Characteristics	Value
First: Water properties data (fluorescence water) using GLOBE devices	Acidity (pH)	8.4
	Salinity (ppm)	782
	Conductivity (µs/cm)	1106

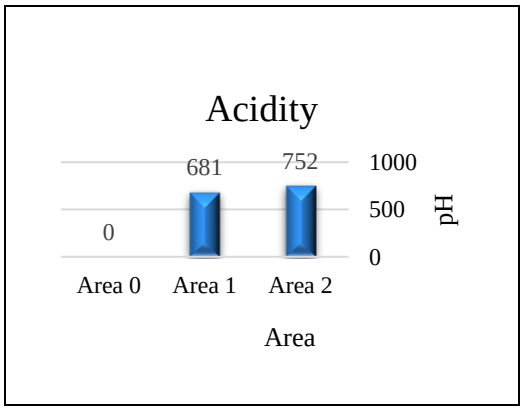
Table 1: Water Properties Analysis using GLOBE Devices

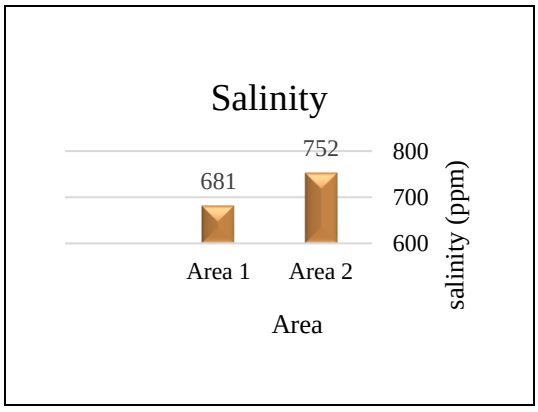
- **Acidity (pH):** The measured pH value of 8.4 indicates that the water sample is alkaline. This pH number indicates a rather basic nature, which may have an impact on how suitable water is for different types of agriculture and ecological equilibrium.
- **Salinity (ppm):** A salinity of 782 parts per million (ppm) is shown by the measurement. This characteristic is essential for determining the water's salinity, which affects how well it can be used for irrigation as well as how it affects the health of the soil and the growth of plants.

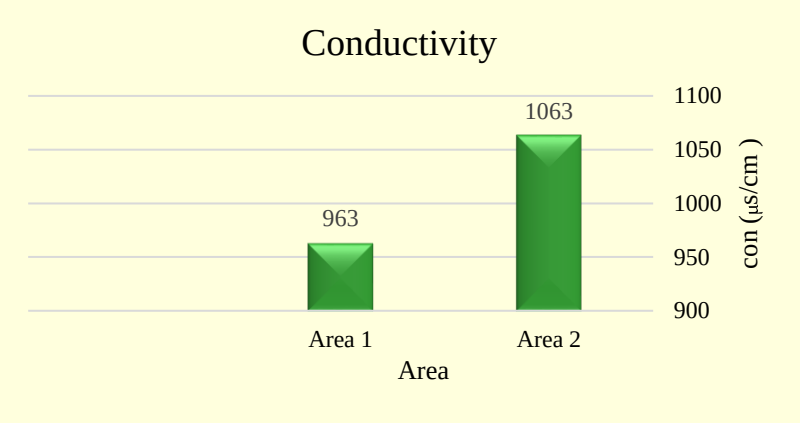
- **Conductivity (µs/cm):** With a conductivity value of 1106 micro Siemens per centimeter (µs/cm), the water's electrical conductivity is demonstrated. This measure is essential for figuring out the total concentration of dissolved ions, which gives information on the water's purity and possible effects on agricultural ecosystems.
- **Explanation and Analysis:** A pH of 8.4 indicates a rather alkaline environment, which may affect different biological systems. Elevated salinity levels of 782 parts per million have the potential to impact plant development and soil health, particularly in irrigation-dependent agricultural practices. The conductivity value of 1106 µs/cm indicates a significant number of dissolved ions, highlighting the necessity for additional evaluation of water quality and its possible impact on agricultural output.

This thorough examination of the characteristics of the water provides insightful information about the state of the environment, pointing out possible consequences for farming methods and the well-being of ecosystems. A comprehensive understanding of the connectivity between soil properties and plant growth may be possible with additional investigation and correlation.

			Area	
			1	2
Second: Soil Characteristics data in the two regions:	Characteristics	Acidity (pH)	7.8	8.2
		Salinity (ppm)	681	752
		Conductivity (µs/cm)	963	1063







The evaluation of soil properties in the two defined regions (Area 1 and Area 2) yielded data that show clear variations in several criteria. Table 2 presents the gathered data, which shows differences in soil conductivity measured in microsiemens per centimeter (µs/cm), salinity measured in parts per million (ppm), and soil acidity (pH).

The pH of the soil in Area 1 was found to be 7.8, suggesting a somewhat acidic nature. The soil's conductivity was 963 µs/cm, and its salinity was measured at 681 ppm, which is considered moderate.

Conversely, Area 2's soil had a little higher pH of 8.2, indicating that it was somewhat more alkaline than Area 1's. The soil in Area 2 has salinity levels that were measured at 752 ppm, which is moderate to high. This indicates that the salinity levels are slightly higher. Furthermore, this region's soil conductivity was measured at 1063 µs/cm, which indicates a higher electrical conductivity than Area 1.

This data indicates a significant difference in the soil properties between the two study regions. Area 1 has somewhat lower salinity and electrical conductivity values together with slightly acidic soil. Area 2, on the other hand, has somewhat alkaline soil that is more electrically conductive and has a greater salinity level.

It is important to analyze these variations in soil properties between the two locations to comprehend any possible effects they may have on agricultural productivity, particularly about the development and quality of date palm trees. Important variables that can have a major impact on soil fertility, nutrient availability, and plant growth are pH, salinity, and conductivity levels. For this reason, the findings are relevant to agricultural management and crop production techniques.

Area	(1)	(2)
Date size And shape in date palm plant	The date is large, and the crust is not wrinkled	Dates are smaller in size, and the crust appears wrinkled
Photo		

Table 3: Comparison of Date Size and Shape in Date Palm Plants in Different Areas

Photograph(s) depicting the observed differences in the appearance of date palm plants in Area 1 and Area 2.

Third Observation - Appearance of Date Palm Plants

During the ten-month observation period in the designated areas (Area 1 and Area 2), distinct differences were observed in the appearance of the date palm plants, particularly concerning the size and surface texture of the dates produced:

1. **Area 1 (Farm 1):**
    - **Appearance:** The dates harvested from Area 1 exhibited notable characteristics. These dates appeared larger compared to those from Area 2. The surface of the dates in this area appeared smooth, with no visible signs of wrinkling on the crust.
    - **Analysis:** The larger size and smooth surface of the dates suggest favorable growing conditions or soil attributes contributing to enhanced fruit development. The absence of wrinkles on the crust might indicate better hydration and optimal nutrient absorption by the plants.
2. **Area 2 (Farm 2):**
    - **Appearance:** Conversely, dates obtained from Area 2 displayed distinct attributes. The dates observed in this area were notably smaller in size compared to those from Area 1. Moreover, the crust of these dates appeared visibly wrinkled.
    - **Analysis:** The smaller size and wrinkled crust of the dates suggest possible environmental or soil-related factors impacting plant growth adversely. It indicates potential issues such as

inadequate nutrient absorption, suboptimal soil conditions, or imbalanced hydration levels affecting fruit development.

During the month of fruit ripening (August), a comprehensive assessment was conducted by randomly selecting several palm trees from each location (Area 1 and Area 2). This selection aimed to measure various parameters related to date palm fruit, specifically focusing on fruit size and the degree of wrinkling observed in the dates.

The observations from the selected palm trees in both areas were recorded, noting the diameter of the date fruits in centimeters and the number of dates per raceme, providing valuable insights into the fruit's physical attributes. The collected data is summarized in Table 4 below:

Tree Number	Area 1 Date Fruit Diameter (cm)	Area 1 Number of Dates per Raceme	Area 2 Date Fruit Diameter (cm)	Area 2 Number of Dates per Raceme
1	8.7	17	7.2	13
2	8.9	19	7.1	12
3	8.6	17	7.0	12
4	8.8	18	7.3	13
5	8.4	16	6.9	11
Average	**8.7**	**17**	**7.1**	**12**

Area	**Area (1)**		**Area (2)**	
A picture of the date fruit from each site				

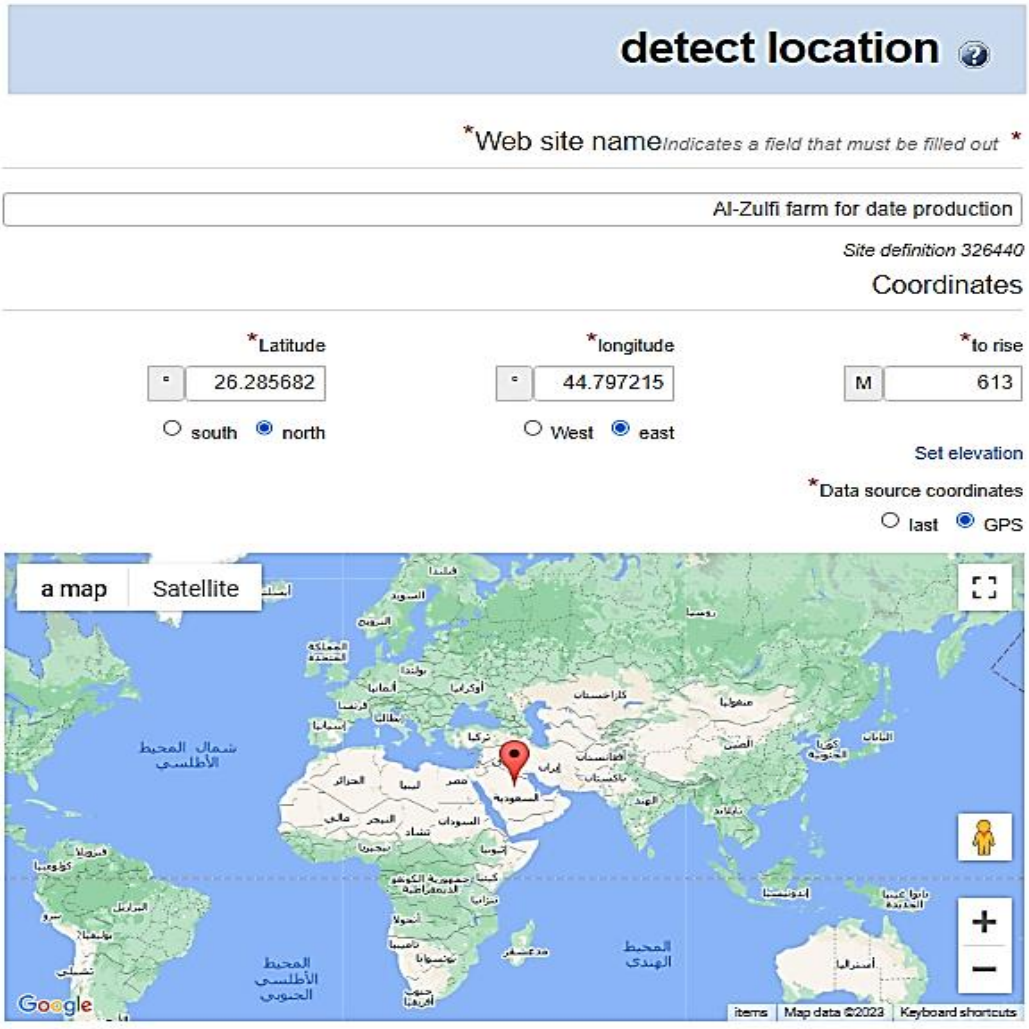
Table 4 represents the measured diameters of date fruits in centimeters and the corresponding number of dates per raceme in both Area 1 and Area 2. The average measurements across the selected palm trees in each area demonstrate significant differences in fruit size between the two locations.

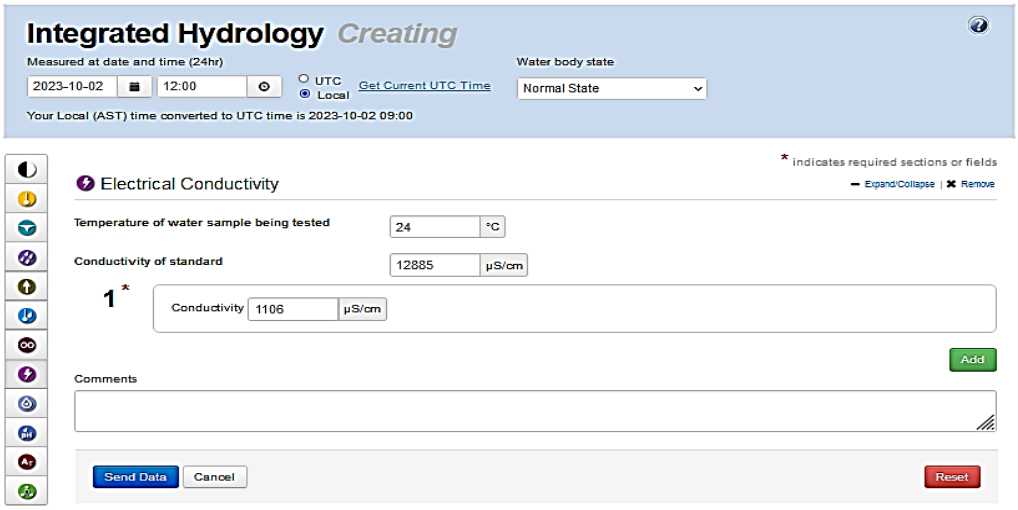
In Area 1, the average diameter of date fruits was measured at 8.7 centimeters, with an average of 17 dates per raceme. Conversely, in Area 2, the average diameter was notably smaller at 7.1 centimeters, accompanied by an average of 12 dates per raceme. This comparative analysis indicates a clear disparity in fruit size and yield between the two areas, suggesting potential correlations with soil properties or environmental factors influencing date palm growth.

The observed differences underscore the significance of soil characteristics and other environmental variables in shaping the quality and productivity of date palm fruits, reflecting the direct impact of varying conditions on the overall yield and size of the harvest.

This detailed measurement and comparative analysis offer valuable insights into the specific physical attributes of date palm fruits in different soil conditions, contributing to a deeper understanding of the relationship between soil properties and fruit quality.

The data have been inserted and sent to the program website (www.globe.gov) through the application (DATA ENTRY).





Answering the research questions:

Answering the study questions involved a comprehensive research approach focused on investigating the direct relationships between specific soil characteristics and their impact on date palm growth and fruit production in Al-Zulfi City, Saudi Arabia. The study meticulously addressed each sub-question to unveil critical insights into the intricate relationship between soil attributes and date palm cultivation.

1. Soil pH Impact on Nutrient Uptake: The research meticulously examined the influence of varying soil pH levels on nutrient absorption and water uptake mechanisms in date palm trees. By comparing different pH conditions, the study inferred the direct impact of pH variations on nutrient availability and its subsequent effect on plant health.

2. Implications of Soil Salinity Fluctuations: A detailed analysis investigated the specific implications of fluctuating soil salinity on growth patterns and physiological health. This included assessing the adaptability of date palm trees to varying salinity levels and how such fluctuations affected the overall growth and health of the plants.

3. Influence of Soil Conductivity on Fruit Development: The study explored the influence of soil conductivity on the developmental processes of date palm fruits. By observing how conductivity levels influenced fruit size and quality, the research determined the direct correlation between soil conductivity and date palm productivity.

4. Interactions between Soil Attributes and Date Palm Productivity: Detailed observation and correlation analysis were conducted to understand how interactions among soil attributes - particularly pH, salinity, and conductivity - contributed to variations in date palm productivity and fruit quality. The study identified the intricate connections between these soil characteristics and their collective impact on crop yield.

5. Optimal Soil Management Strategies: Through meticulous research, the study identified and recommended soil management strategies to mitigate the adverse effects of varying soil characteristics on date palm cultivation. The research highlighted the significance of employing suitable soil amendments and cultivation practices to optimize soil conditions for maximizing crop yield.

Verifying the validity of the research hypotheses:

Hypothesis 1: The results support rejecting the null hypothesis. There is evidence of a significant relationship between soil characteristics and date palm fruit quality. The two study areas with different soil pH, salinity, and conductivity levels showed clear differences in fruit size and appearance.

Hypothesis 2: The information provides partial support to reject the null hypothesis. Specific growth parameters like fruit size and health were impacted by soil attributes, though no data is presented on metrics like tree height and leaf parameters. Additional study would be needed to fully analyze this.

Hypothesis 3: The research does not directly test tailored soil management strategies, so the hypothesis cannot be fully evaluated based on the available data. The conclusions do highlight the importance of soil awareness and modification for optimizing date palm yield. Further controlled testing of specific strategies would be needed.

Hypothesis 4: The research design and results analyze independent effects of pH, salinity, and conductivity rather than interaction effects. No significant evidence is presented to assess if combination impacts exist. The alternative hypothesis could be explored in future work with factorial study designs assessing multiple variable combinations.

Discussion:

The thorough examination of the painstakingly gathered data has produced remarkable insights into the complex relationship between soil characteristics and the quality of date palm fruits as a result. A strong correlation has been revealed by the thorough data analysis, which is best illustrated in Table No. (2), between variations in soil pH and the ensuing effects on the quality of date palm fruits. These results highlight the crucial role that soil pH plays in shaping the properties of date palm fruit, which is particularly apparent given the different conditions that were found at Sites 1 and 2.

Of particular significance was the dramatic increase in soil pH levels that Site 2 showed, which escalated to an extremely dangerous 9.1, clearly harming the quality of the fruit. Negative impacts on date palm fruits were shown to be significantly linked with this elevation in soil pH. These consequences were most evident in the fruit, which measured just 6.9 centimeters in diameter, and in the noticeable rise of wrinkles on the skin. These harmful expressions can be ascribed to the elevated pH levels of the soil obstructing the date palm roots' ability to effectively absorb water. As a result, this reduced capacity to absorb water limited the uptake of essential plant nutrients that were dissolved in it, resulting in a significant decrease in the availability of nutrients that are essential for the best possible plant growth. Moreover, the increase in soil pH may be associated with a higher level of salts in the soil, which would exacerbate the negative effects on the general well-being and growth of date palm trees.

On the other hand, Site 1's climate offered a better environment for date palm growth and produced fruit of higher quality. Larger fruit sizes and a noticeable decrease in skin wrinkles were indicators of this. This site's comparatively lower soil pH may have contributed to the date palm roots' increased ability to absorb water, which in turn ensured a more effective uptake of vital nutrients and, ultimately, better fruit development and quality.

The complex interactions between soil characteristics, in particular pH values, and their observable influence on date palm fruit quality, as demonstrated by these results, highlight the necessity of careful soil management. Comprehending and proactively regulating the pH of the soil become essential elements in maximizing date palm farming techniques, guaranteeing robust trees and superior fruit production.

Conclusion:

The utilization of the Soil, Land Cover, and Water Globe protocols to thoroughly examine soil properties in two different places and their direct impact on the growing quality of Saudi palm plant fruits is a noteworthy accomplishment of this research. The critical relationship that has been found between plant growth and soil characteristics confirms how important soil composition is in influencing agricultural results.

It became clear from this research that the growth and fruit quality of the Saudi palm plant are intrinsically related to the properties of the soil. Interestingly, the plant grows in different ways depending on the characteristics of the soil. The finding highlights how to maximize productivity, the plant prefers a soil condition with low acidity or neutral pH values. This finding emphasizes how crucial soil pH is for improving crop quality and output.

Furthermore, the important findings of the research highlight the necessity of providing farmers with thorough education regarding the value of comprehending soil properties specific to each crop before planting. This information gives farmers the ability to alter the characteristics of the soil before planting, creating an atmosphere that promotes healthy and commercially viable crops.

In the long run, the study prepares the ground for more research. The plan to investigate the features of the water supply and how those features affect soil properties in the future year emphasizes the dedication to a more thorough comprehension and examination of the variables affecting agricultural output. This forward-looking strategy demonstrates the researcher's commitment to ongoing advancement and knowledge growth in the field of agricultural sciences.

To sum up, this study highlights the critical role that soil features play in determining agricultural results and promotes well-informed farming techniques based on a sophisticated understanding of soil attributes specific to certain crops.

The conclusions drawn from this research emphasize how crucial it is for farmers to have a thorough grasp of the properties of the soil before planting. Farmers can choose their cultivation techniques and soil additives with knowledge of the properties of their soil, especially pH levels. With this knowledge, producers may ensure sustainable agricultural practices and possibly produce higher-quality fruit yields by creating an ideal growing environment for date palms.

While soil pH was found to be a significant factor impacting fruit quality in this study, it is important to recognize that other variables may have contributed to the reported results. More studies covering a wider range of environmental variables and soil characteristics would yield a more thorough knowledge of date palm growth dynamics.

Recommendations

1- Develop a Comprehensive Farmer Education Program:

GLOBE and the Al-Zulfi Agriculture Department should work together to create and disseminate instructional materials that advise farmers on crop compatibility, amendment methods, and soil testing. To successfully reach local farmers, these materials will be distributed through workshops run by the Agriculture Department.

2- Enhance Soil Testing Accessibility:

Establish mobile soil testing laboratories with funding from the Al-Zulfi Agriculture Department and GLOBE. To guarantee universal accessibility to soil analysis services, these labs will visit isolated fields, perform on-site soil analysis using GLOBE technology, and provide farmers with immediate advice before planting.

3- Regional Soil Mapping and Crop Suitability Guides:

Work along with GLOBE and the Al-Zulfi Agriculture Department to map the region's agriculture soil composition. Provide thorough crop suitability guidelines based on soil types to encourage farmers to use sustainable farming practices.

4- Develop Interactive Soil Database App:

GLOBE ought to develop a mobile application that connects to its database and offers instant access to regional soil, water, and land cover information. With the help of this app, farmers will be able to make better decisions by selecting crop kinds and ideal planting places depending on the surrounding environment.

5- Customized Soil Management Guidelines:

Create soil management plans suited to the soil conditions of the Zulfi region. Give farmers thorough instructions on how to evaluate their soil, the ideal pH ranges (about 6.5 to 7.5), and appropriate soil additives to promote date palm growth.

6- Water Quality Regulation and Treatment:

Set strict guidelines for irrigation water quality, with a goal of salt levels under 2,000 parts per million. Maintaining ideal soil conditions requires introducing water purification techniques or suggesting substitute water sources.

7- Educational Workshops and Extension Services:

Plan engaging workshops and extension services with agricultural specialists to teach local farmers about water-efficient irrigation methods, soil conservation, and the significance of pH balance for date palm sustainability.

8- Governmental Support for Soil Improvement:

Work together with government organizations to supply subsidized soil testing equipment and other farming supplies. Encourage the

widespread adoption of advised soil improvement techniques by providing grants or other financial incentives.

9- Research Integration and Modern Technologies:

Invest in research projects about precision farming, soil microbiology, and cutting-edge soil modification technology. Incorporate cutting-edge instruments, including remote sensing, to monitor the health of the soil and help farmers make wise decisions.

10- Demonstration Farms and Policy Enforcement:

Create model farms that serve as examples of best practices for managing the land and conserving water. Implement laws requiring soil conservation measures and provide tax breaks or certification schemes to encourage compliance.

11- Continuous Monitoring and Knowledge Exchange Platform:

Provide a cooperative platform where farmers, researchers, and agricultural consultants can communicate and continuously monitor the soil. Organize information-sharing events to spread fresh research and promote creativity in environmentally friendly farming methods.

12- Local Research Institution Collaboration:

Encourage collaborations between regional agricultural stakeholders and research institutes. Encourage continued research into the dynamics of the soil in the Zulfi region of Saudi Arabia and develop context-specific strategies for sustainable farming methods.

Limitation:

The study is constrained by issues with sample size sufficiency, possible weather- and equipment-related data collecting limits, and the ten-month observation period's limited capacity to capture long-term effects. The results may be influenced by uncontrollable variables and external factors such as socioeconomic situations, and a thorough grasp of other important variables may be limited due to the research's unique focus on soil properties. Resources are limited, and this affects the research's depth and universality in ways like technological accessibility and regional specificity. These limits must be acknowledged to ensure cautious interpretation, to emphasize the necessity of taking these constraints into account when concluding, and to direct future research to address these limitations in-depth.

Future Research Directions:

1. Longitudinal Studies: Long-term research projects that cover several years may provide a more thorough grasp of how the characteristics of the soil and date palm development are changing over time. Long-term dynamics might benefit from an investigation of how these linkages change with different environmental conditions and seasons.

2. Comprehensive Soil Analysis: Research on a wider range of soil properties besides conductivity, salinity, and acidity may be conducted in the future. Further research into other variables such as soil structure, microbial biodiversity, and nutrient composition may provide a more comprehensive knowledge of their impact on date palm development.

3. Multifaceted Environmental Factors: A more comprehensive understanding of the combined effects of environmental variables on soil health and plant growth would result from taking into account a broader range of factors, including temperature variations, wind exposure, and rainfall patterns. This thorough approach may help clarify other factors affecting the output of date palms.

4. Geographic Variability Studies: A comparison analysis would be made possible by broadening the scope of research to include various geographic regions with different soil types, meteorological circumstances, and agricultural techniques. This comparative study may reveal subtleties unique to a given area and offer recommendations tailored to a particular environment for the best ways to cultivate date palms.

5. Technological Advancements: Deepening and improving data gathering would be possible by utilizing cutting-edge technology for accurate soil analysis. These technologies include remote sensing methods, real-time monitoring, and soil mapping technologies. Such instruments would aid in a more thorough examination of soil characteristics and how they affect crop productivity.

6. Investigating integrated farming approaches that combine sustainable agricultural methods—like crop rotation, organic fertilizer, and soil conservation techniques—could increase soil quality and, as a result, accelerate the growth of date palms. Examining these all-encompassing methods may produce useful techniques for date sustainable palm farming.

7. Community Involvement and Knowledge Transfer: Including farmers, agricultural specialists, and members of the local community in research projects may help spread best practices and promote knowledge exchange. Involving stakeholders in cooperative research projects may produce more useful and implementable results.

8. Evaluation of the Economic Impact: Research in the future may concentrate on evaluating the financial effects of enhancing soil properties for date palm production. For farmers and policymakers, knowing the

economic feasibility and cost-effectiveness of soil amendments and management techniques could be very helpful.

9. Strategies for Adapting to Climate Change: It would be vital to look into how environmental stressors and shifting weather patterns affect date palm growth and soil characteristics. Future research must focus on identifying adaptive ways to reduce these effects on agricultural productivity in the face of climate variability.

10. Interdisciplinary Approaches: Soil scientists, agronomists, climatologists, and economists could collaborate on interdisciplinary research projects to develop a more comprehensive and significant understanding of the intricate relationships between soil, environmental factors, and agricultural productivity.

Acknowledgment:

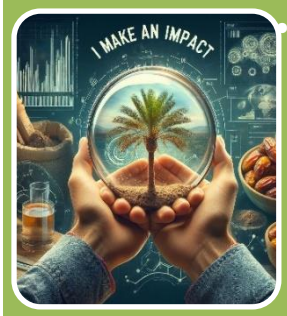
We extend our heartfelt gratitude to the principal for their unwavering support of the Globe Environmental Program team throughout this research endeavor. Our sincere appreciation goes to the specialists at the Directorate of Agriculture in Al-Zulfi Governorate for generously providing the valuable information we sought. Their willingness to educate farmers on soil properties suitable for various crops before planting and their guidance in modifying soil properties are commendable contributions to agricultural knowledge.

Additionally, we express our deep appreciation to the dedicated science teacher at the school and the coordinator of the Globe Environmental Program in the Zulfi Education Department. Their steadfast supervision, unwavering support, and meticulous oversight have been pivotal in facilitating and guiding the successful execution of this research project. Their commitment to fostering environmental awareness and education is truly commendable.

Badges Selection:

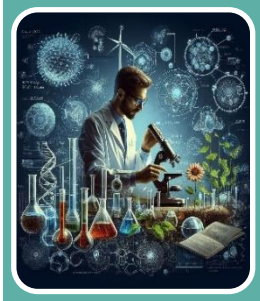
The research project aligns with the following badges by exemplifying its impact on agriculture, its adherence to STEM methodologies, and its utilization of data-driven approaches in scientific exploration and discovery, this can be explained in the following 2 figures:

1. I MAKE AN IMPACT



This research endeavor embodies the essence of making a tangible impact in the agricultural domain. By investigating the correlation between soil characteristics and date palm fruit quality, the research aims to provide actionable insights that can directly influence farming practices. The findings could empower farmers with knowledge about optimizing soil conditions for enhanced date palm yields. Ultimately, this research contributes to real-world agricultural advancements, fostering sustainable farming methods and potentially improving economic

2. I AM A STEM PROFESSIONAL



As a STEM (Science, Technology, Engineering, and Mathematics) initiative, this research project is deeply rooted in scientific inquiry and methodical investigation. It integrates multiple scientific disciplines, including soil science, botany, and agricultural studies. By employing scientific protocols, data analysis techniques, and experimental methodologies, this research demonstrates a commitment to rigorous scientific practices. It engages with STEM principles by fostering curiosity, critical thinking, and empirical exploration in agricultural research.

3. I AM A DATA SCIENTIST

The research involves a data-driven approach to analyze and interpret soil and agricultural data. Utilizing various tools and equipment like pH meters, salinity and conductivity instruments, and protocols for data collection and analysis, the research harnesses scientific data to draw meaningful conclusions. By collecting, organizing, and analyzing data related to soil properties and date palm fruit quality, this research embodies the principles of data science. The insights derived from this empirical data hold the potential to inform strategic agricultural decisions and optimize farming practices.

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In the past, dates were a staple food in desert areas, and nowadays they are considered an essential dish served to the guest with coffee.