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Soil characteristics and their Effect on the quality of red onion plant In Al Zulfi Governorate

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Abstract

This research aims at establishing the relationship between the quality of red onion plants in Al-Zulfi city, Saudi Arabia and soil type. Mineral, particularly acidity, salinity and conductivity on bulb quality which is the most vital part of the plant is assessed and most important for the farmer, with the intention of finding out the correlation between the physical disposition of the soil and the quality of the red onion plant. The main research question is therefore based on investigating how differential properties of the soil impact on the growth and quality of red onion plant. The study goals are focused on the contrast of the two regions which have the similar water quality but different types of the ground, Area 1 and Area 2. It examines the consequent impacts on red onion quality, and observation was done at the beginning of plant cultivation in October. These finding suggest a positive correlation between the soil pH levels and quality of onions produced. These changes included a smaller onion (17.5 cm diameter) found at Area 2 with a higher pH (pH 8.1) than onion found at Area 1 with better soil conditions. The guidelines promote proper soil conservation practice and underline the need for application of knowledge by farmers in respect of soil properties before planting takes place. This calls for selecting the right plants, using the right irrigation system, applying the required fertilizers, and contacting the agricultural authorities for soil analysis in case of low crop production. In conclusion, the study emphasizes on the role of soil properties, particularly the acidity, in quality of red onion plants. Farmers who would know the properties of their soils can improve soil conditions and therefore enhance crop yields.

1. Introduction

Red onion plant production has always been one of the major agricultural activities engaged within the Al-Zulfi region of Saudi Arabia for the reason that onions are part of the staple diet; therefore, they have been commanding a high economic value in the locality. However, under such conditions, it is hard to achieve full development and realize the potential for quality and yield in red onions due to limiting factors that relate to soil salinity, pH, organic matter, and soil texture. Such an understanding of factors affecting soil would be very crucial in influencing the growth and quality of red onions under arid climatic conditions, challenges, and poor quality of any agricultural undertaking on it. (Bhardwaj et al., 2022)

1.1 Background and Rationale

The climate of Al Zulfi Governorate is very hot continental in summer, where the maximum temperature during the day reaches 42 degrees Celsius, and cold in winter, where the minimum temperature drops in some cases to below zero degrees Celsius. The humidity rate is low throughout the year, especially in the summer, while the annual rainfall rate ranges between 90-110 mm annually. The negative impact of the climate condition is reflected in the soil, as these reasons have led to a decrease in soil fertility and an increase in its salinity, and thus poor health and decreased crop production. Previous studies have indicated that high salinity levels negatively affect the physiological processes of the plant, which hinders growth and quality. In addition, changes in soil acidity affect the availability of nutrients and the ease of their absorption by the plant, which leads to a decrease in the quality of the red onion plant. The application of organic matter is essential to improve soil fertility and its ability to retain water because it enhances biological activity and nutrient cycling. This will determine how these soil characteristics are related to the quality of the red onion plant, which will be essential in improving agriculture in the region. (Mohsen Jan Mohammadi and Nasser Sabbaghniyeh, 2023)

2. Research Objectives

- Investigate the impact that salinity in the soil contributes to growth and quality traits in the red onion plant varieties within the Al-Zulfi region in terms of a bulbing size, overall crop yield, and/or the flavor profile of the formed bulbs.
- Determine if and how various soil pH values affect nutrient availability as it relates to growth/quality parameters in red onion pant varieties.
- Assess the effect of conductivity and how it affects water retention, nutritional availability, and general plant health.
- To ascertain the influence of soil texture on growth conditions concerning water retention and aeration with regard to the formation of the bulb in red onions.

- Recommendation on good practices in the context of sustainable soil management through selected findings regarding the characteristics that influence soil's impact on red onion plant quality to ultimately develop the utmost agricultural productivity in the Al-Zulfi region.

The results of this research will be quite enlightening and will add to the knowledge in the cultivation of the red onion plant, hence contribute to more sustainable agricultural practices in conditions similar to those represented by the Al-Zulfi region.

3. Literature Review

The soil characteristics that will help explain the quality of the red onion plant have to be based on the composition, the structure, and the availability of nutrients within the soil. These aforementioned factors will highly affect plant health, growth, and the quality of the yield.

3.1 Soil Composition and Structure

Soil composition refers to the various substances that constitute the soil, mainly mineral particles, organic matter, water, and air. On its part, the structure would be three-dimensional disposition or configuration that outlines the manner in which the different components of the soil relate to each other in support of plants. These soils, which are common in the area, are mainly sandy loams to clayey in texture and thus have possible implications for agriculture. (Schlüter & Koestel, 2022)

Researcher has shown that: The Palu Valley variety of red onion plant represents a specific classification of shallot that demonstrates optimal growth conditions within the geographical confines of the Palu Valley and its adjacent areas. Its unique flavor profile, when subjected to frying, renders it a notable culinary souvenir from the city of Palu. The primary objective of this study was to investigate the physical properties of soil in regions frequently cultivated with shallots. This research was executed in Guntarano Village, located within the Donggala Regency. Soil samples were systematically analyzed at the Laboratory of Soil Science, under the auspices of the Faculty of Agriculture at the University of Tadulako. The duration of this research spanned from June to November 2022. A survey method was employed, with the research locale being selected intentionally through purposive sampling. Soil samples were collected from shallot cultivation areas situated on flat terrain as well as the backslope. Based on the expanse of the land, five composite samples were obtained, with each composite representation encompassing between 5 to 10 observational points. The analytical results regarding the physical characteristics of the soil indicated that the shallot cultivation fields exhibited a crumb to lumpy soil structure; medium to heavy bulk density; soil organic matter levels ranging from medium to high; and water content at field capacity varying from 16.12% to 22.85%. The soil within the shallot farming region has begun to exhibit declining quality, attributable to elevated soil porosity (66.09%) and significant

soil permeability (13.10 cm/hour). Additionally, the proportion of sand, silt, and clay that the soil contains is incredibly crucial for improving fertility and biological functioning of the soil. This study has revealed that the incorporation of organic matter enhances the physical features of the soil including reducing soil erosion and degradations that is highly vital in the arid areas of Al-Zulfi. Hence, it is very essential to determine the character and content progressively constituting Al-Zulfi soils for optimal growth of red onion plant. (Monde et al., 2023)

Field experiments were conducted during the dry seasons of 2012-2013 and 2013-2014 to investigate the effects of Integrated Nutrient Management on various soil properties and nutrient assimilation by red onion plant (Allium cepa L.) in Moda, Michika, Adamawa State, Nigeria (Kwaghe et al., 2017). Soil samples were systematically collected and subjected to analysis for pH, electrical conductivity (EC), organic carbon content, organic matter, total nitrogen, and available phosphorus prior to and upon the conclusion of the experimental period. The concentrations of total nitrogen, phosphorus, and potassium in the onion bulbs were quantified. An enhancement in the fertility status of the soil was observed as a direct result of the implementation of integrated nutrient management practices. The application of combined organic and inorganic fertilizers significantly affected the absorption of nitrogen, phosphorus, and potassium by red onion. The maximum absorption rates of nitrogen, phosphorus, and potassium by the onions, quantified at 0.76, 43.82, and 2.42 kg ha-1 respectively, were recorded when all treatment modalities were integrated. The uptake of nitrogen and potassium exhibited a positive correlation with the increasing levels of treatment. The phosphorus uptake peaked at lower treatment levels, which may be attributed to the sufficiency of indigenous soil phosphorus for optimal plant growth, thereby facilitating substantial phosphorus uptake with minimal nutrient input. The adoption of Integrated Nutrient Management practices could be a viable strategy to enhance soil fertility and the uptake of nitrogen, phosphorus, and potassium by red onion plant.

To assess the variability of soil physicochemical conditions in bulb onion cultivation, a total of 15 zones measuring 50 × 50 m were examined within the Usochicamocha irrigation district. A comprehensive collection of 15 soil samples and 15 irrigation water samples was conducted, followed by subsequent laboratory analyses. Data regarding pH, organic matter (OM), electrical conductivity (EC), bulk density, soil texture, calcium (Ca), magnesium (Mg), potassium (K), sodium (Na), phosphorus (P), ion load, cations, hardness, and turbidity in the water samples were obtained. The findings revealed a significant correlation between crop attributes and the physicochemical properties of soil and water across the various study zones. These results substantiate the hypothesis positing the existence of a synergy between the extrinsic and intrinsic characteristics of the crop and their interrelation with the quality attributes of the bulb onion yield**.** (Nicolás Forero-Pineda et al., 2022)

Soil salinity significantly hinders irrigated agriculture, especially in onion production (Ado Maman Nassirou et al., 2024). This study aims to assess the impact of soil salinity on various onion cultivars in Niger's Tahoua region. Utilizing a block factorial design, three onion varieties were examined across four electrical conductivity levels to evaluate growth, biomass, and bulb yield. Results indicated a reduction in leaf number, height, and diameter with rising salinity levels for all varieties. Additionally, premature growth cessation due to wilting occurred in high salinity conditions after 60, 48, and 56 days for V1, V2, and V3, respectively. Bulb yield, ranging from 896 to 8000 kg/ha, significantly declined with increased soil EC. Compared to control conditions, higher salinity levels led to a 43 to 88% reduction in bulb yield, notably affecting V1 and V3 varieties. Under the local variety, bulb yield in control conditions surpassed that of S1 and S2 by 3.2 and 8.7 times, respectively. Nonetheless, V2 demonstrated superior tolerance to soil salinity compared to V1 and V3 in terms of growth and yield. Therefore, this research highlights the detrimental effect of soil salinity on onion cultivation in Niger.

4. Research Problem

Red onion plant production in the Al-Zulfi area in Saudi Arabia is problematic because of the impact of adverse influences of soil properties including salinity, pH, organic matter and texture of the soil. It also indicates these factors did not only affect the yield and quality of the onions but also a reality for sustaining agriculture in the arid climate.

Key Issues

- **Soil Salinity**: The arid region of Al-Zulfi which receives very low rainfall, has high evaporation and salinity is investigated for its influence on the proximate composition, growth, nutrient uptake, and quality of red onion plant under high salinity stress. (Md. Ashraful Alam et al., 2023)
- **Soil pH Variability**: Changes in soil pH create conditions that cause nutrient levels to rise or decrease, which hampers the physiological growth of red onion plant. Since plants require optimum levels to utilise nutrients, pH levels are important for usability. (Barrow & Hartemink, 2023)
- **Soil texture**: The other factor is that various qualities of soil impact water-holding capacity, permeability, and root penetration, on which bulb formation in onions is dependent. Knowledge of how these textures affect other soil properties is necessary when enhancing agricultural productivity. (Zahran, 2025)

5. Significance

It is important and relevant research into the aspect of soil characteristics and their impact on the quality of red onion plant with several aspects. It provides practical information on how the physical and chemical characteristics of the soil have an impact on the yield and quality of the crops; therefore, farmers can use this information in managing their soil properly. Overall, this research wants a higher popularity of sustainable farming strategies and people's awareness of soil conditions. In addition, it provides a conceptual framework for subsequent studies on soil-plant relations subsequently promoting agricultural yield in Al-Zulfi region and food security.

6. Research Questions

The following represents the research question that will provide the basis for the study *Soil Characteristics and their Effect on Red Onion plant Quality*.

- ❖ How different is nutrient uptake and growth among various pH levels in the plant of red onion?
- ❖ How does the oscillation in soil salinity affect growth performance and physiological health in red onion plants?
- ❖ How does soil conductivity influence the growth, yield, and overall quality of red onion plants in relation to their size and nutrient uptake?
- ❖ How are the development and quality of red onion plants affected by the combined effects of soil pH, salinity, and electrical conductivity?
- ❖ Which might be the best management practice indicated in order to reduce negative impacts of different soil types on the red onion plant crop?

7. Research Hypotheses

Hypothesis 1

There is a positive significant relationship exist between the growth and quality of red onion plants and soil's pH nutrients for efficient nutrient uptake.

Hypothesis 2

Increased soil salinity also has the effect of making the bulb that is produced smaller and less marketable than if the red onion plants were grown in a non-saline environment.

Hypothesis 3

Through improved nutrient absorption and the promotion of greater bulb size, higher soil conductivity has a beneficial impact on red onion plant growth, production, and quality.

Hypothesis 4

The soil texture affects the water status and root and string penetration of red onion plants, which in turn affected bulb development and production.

Hypothesis 5

When specific soil management practices like use of organic matter and good irrigation practice are applied there will be a much better yield and quality of red onion plants in arid environments as is the case of Al-Zulfi region.

8. Research Terms

Soil Salinity: It can be described as the concentration of soluble salts in the soil – which in many cases can inhibit plant growth. High salinity reduces water intake and lowers crop productivity and in agricultural fields; alters the soil structure.

Soil pH: It is an index of the soil acidity or alkalinity, and common units are numbers from 0 through 14. This therefore defines the possibilities of nutrients that can be available in the soil, the kinds of micro-organisms that can exist in the soil and the health of the soil.

Soil Texture: It is the proportions of sand, silt and clay fractions in the continuum of the total affected surface layer. Soil texture is a measure of soil's ability to retain water, provide air to the roots and release nutrients as well as the ease with which roots can penetrate the soil.

Nutrient Availability: The presence and availability of nutrients (for example nitrogen phosphor and potash) in the soil which are used by the plant as nutrients. Such factors as soil pH and organic matter are critical in influence nutrient bio availability.

Growth Parameters: They are real numbers and qualities of plant size and health that were measured in the progress of experimentation, such as measurements of bulb, yield, leaf area and plant's general health as regards the effects of the environmental factors and the exchangeable soil solution on the crop benefits.

Red Onion plant Quality: It is pertaining to size, flavor, color, texture as well as nutritive value of red onions. Quality is defined using market norm and customers' desires.

Sustainable Agriculture: It practices that would feed the present population and at the same time maintain the potential of future generations to feed their populations. This implies the long-term conservation, as well as the efficient and effective use of natural resources, minimizing environmental damage, and caring for the ecosystem.

Soil Degradation: It is defined as the process of a soil-geographic area losing its ability to produce effective productivity, such as through erosional processes, salinization, nutrient outflow, and poorly planned use of the area within which the soil lies, which threatens the productivity and sustainability of our agricultural lands and the environment that supports these productions.

Irrigation Practices: It is techniques of getting water to crops to increase food production. The most familiar methods are surface irrigation systems, drip irrigation, sprinkler systems and sub-surface irrigation. These techniques

enhance on the use of water that reduces evaporation, and increase crop yield particularly in areas of low rainfall. All the methods mentioned here differ in effectiveness and implementation. **Agricultural Extension Services:** They are activities undertaken in the form of courses, training, awareness, literature, or other methods to create additional knowledge and awareness, improved farming practices, and techniques in crop husbandry as well as land conservation and management skills for farmers.

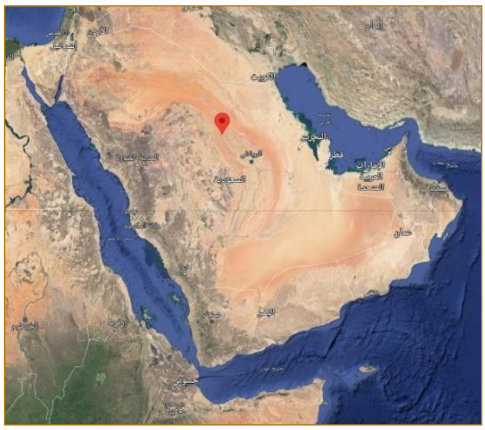
Correlation Analysis: It is a technique used in quantitative research studies in order to determine the extent and direction of the relationship between two variables such as the yield of plants and the physical properties of the soil.

Descriptive Statistics: They are the methods used in the analysis of variability and methods used to characterize some general characteristics such as the average, median, range and standard deviation.

9. Methodology

9.1 Analysis of the Investigation Site and Climate

This research was conducted in Al-Zulfi Governorate, which belongs to the Riyadh Region of the Kingdom of Saudi Arabia. It is a semi-arid to desert climate region (Latitude 26.267044, Longitude 44.771327), influencing substantially the growth of crops and farming methods in the region (*https://data.globe.gov/#/sites/326440/edit?orgid=21849001*).



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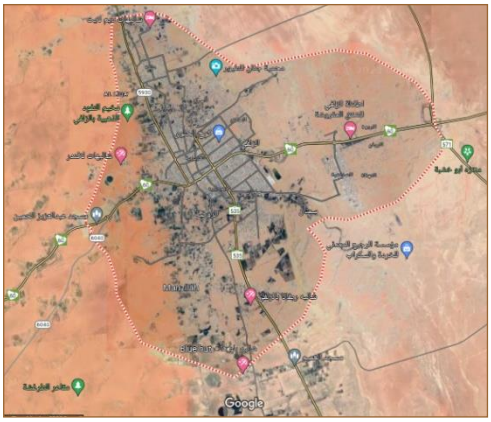
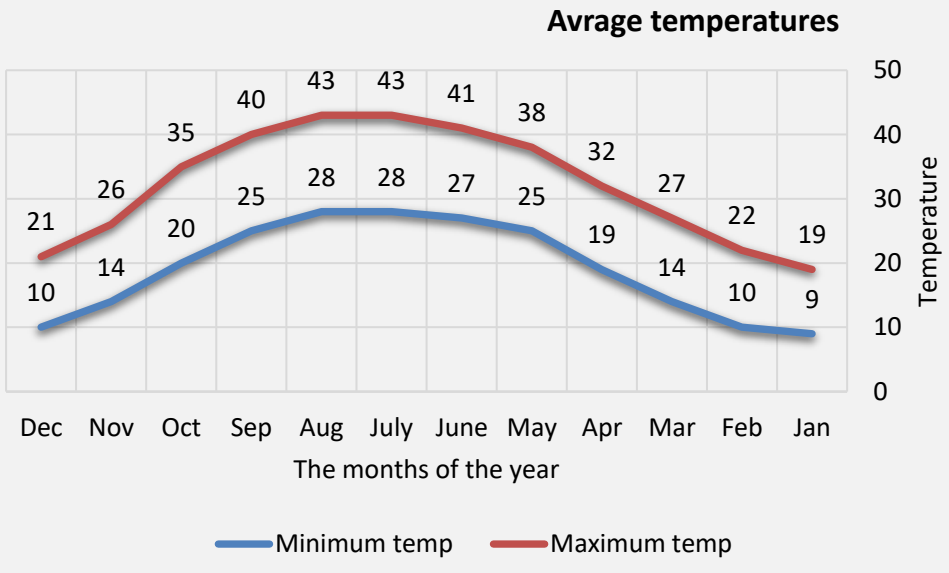


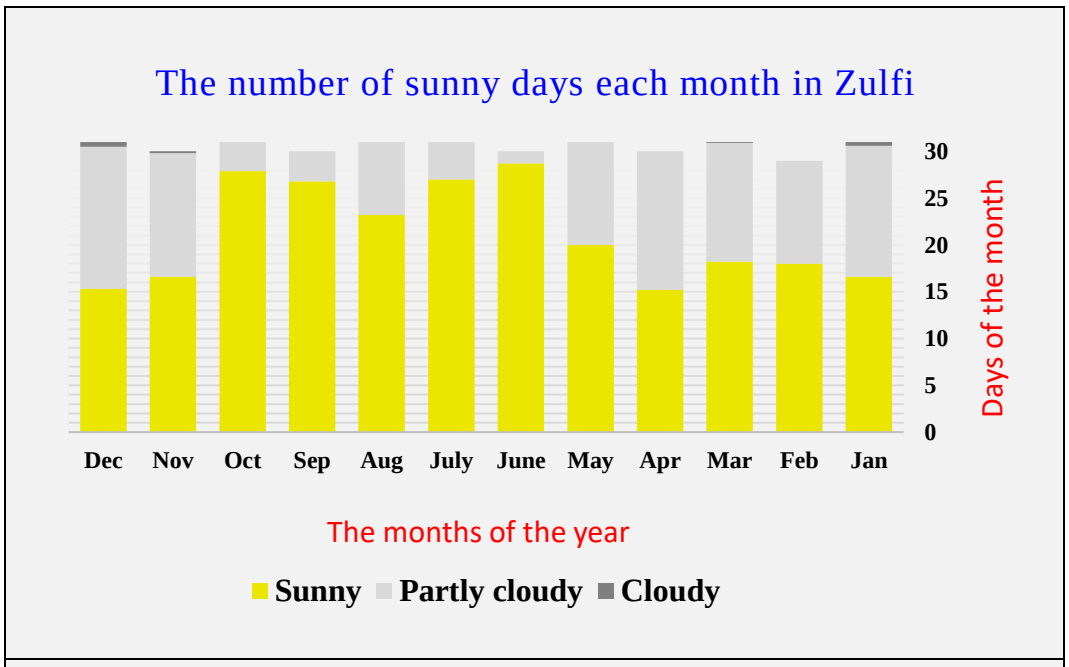
The research location (Governorate of Al-Zulfi)

9.1.1 Overview of the Climate



Average temperatures in Al Zulfi Governorate during the year

https://ncm.gov.sa/ar/Pages/default.aspx



A figure showing sunny, partly cloudy days, cloudy days in Zulfi Governorate

https://ncm.gov.sa/ar/Pages/default.aspx

The climate of Al Zulfi Governorate is characterized by sharp fluctuations in temperature, low humidity and little rainfall. Winter is from December to February. Winter nights are cold and the temperature may drop to zero. During the day, most winter days are clear skies and temperatures range between 9 and 32 degrees Celsius. From March to May, spring is the season when the temperature rises relatively. During the summer months from June to August, the temperature in the shade may reach 45 degrees Celsius. During the fall season, which is between September and November, the temperature begins to drop. The average rainfall during the year in Al Zulfi Governorate in some cases does not exceed 100 mm. (Ministry of Environment, Water and Agriculture)**.**

9.1.2 The Protocol on Water and Land Cover

Investigation in Al-Zulfi Governorate involves some considerations of protocols connected with the aspects of land cover-water use. Included are techniques and methodological procedures, which cover the following:

- **Water protocol**

Water protocol deals with assessing the various sources of water employed in irrigating the soil. This is usually done by taking important readings of variables such as conductivity, pH, salinity, among many others. During the evaluation of these parameters, one may get an insight into the quality of water and its influence on soil properties and development of crops.

- **Land Cover Protocol**

Land Cover Protocol means to perform accurate detailed land cover measurements and assessments, focusing mostly on agricultural landscapes, soils, and vegetation cover. Focus was made on the examination of a range between specific features of the land cover and its further influence on crop yield and specific ways of cultivation.

These specialized techniques enable a thorough and methodical examination of the relationship between environmental factors-primarily land cover and water quality-and how they affect agricultural practices, namely the Al-Zulfi region's red onion plant output.

9.2 Data Collection and Analysis

The research methodology in data collection and analysis is wide and multidimensional in nature, so as to comprehensively look into the study question. An extensive study of soil properties, water quality, and red onion plant traits will be carried out using a variety of techniques and specialised technology, In addition to the Globe Program tools and devices that were provided to us by the program coordinator in the education department in the governorate.

In this respect, a pH meter will be employed during the procedure on soil for correctly measuring the levels of acidity in the soil. To determine the salinity and conductivity of the soil, conductivity and salinity meters will be used in addition to the pH meter. Consciousness of the chemical make-up and its likely impacts on the plants with respect to the quality of the red onion plant requires awareness of these features.

With these considerations, the conduct of these various processes, further supported by special equipment to conduct tests on soil, water, and plants, shows a wide-ranging method of data collection. Guided by this multidimensional approach, researchers will be capable of collecting detailed and accurate data that would backing a comprehensive research and, thus, a complete knowledge of the different affecting red onion plant production.

9.2.1 Methods of Data Collection

9.2.1.1 Selection of research Areas

Two different locations were selected for the experiment based on a single water source used by them, the quantity of water used by them being the same and their exposure to light being the same. The most critical factor that differentiated both regions was the type of soil, which the experiment considered the independent variable. The selection process tried to keep the other variables constant to achieve the effect of different soils on the growth and development of the red onion plant.

		
Onion plant cultivation		Distribution stage of onion plants

9.2.1.2 Sampling and Analysis

Careful attention was paid to the gathering of soil and water samples from the appropriate locations. They were then put through a complex analytical procedure wherein specialized Globe tools were used to evaluate acidity, salinity, and conductivity. These are required to be precise for any evaluation and comparison of the soils' quality to be done correctly.

Researchers **Faris** and **Dhari** while collecting soil and water samples from the specified sites, then subjecting them to an analytical procedure to evaluate acidity, salinity and electrical conductivity using Globe software tools and recording the readings.

Some of the tools and materials used in the field study to examine soil characteristics in the two regions

9.2.1.3 Observations of the Red Onion Plants

From each of these two areas, two sites were closely monitored for the same-species red onion plant. This step is foreseen to directly allow the comparison of the growth responses due to altered soil conditions, as it ensures the plant samples under study are kept constant.

9.2.1.4 Standardized Organic Fertilization

To ensure uniformity and eliminate extraneous factors, the soil was treated identically in both test locations using the same quantity of organic fertilizer and according to the same timetable. This uniform fertilization technique aimed to create equitable growing conditions for red onion plant by promoting plant development equally in both locations.

9.2.1.5 Complementary Comparison of onions Quality

Due to careful observation, comprehensive comparison of the quality by red onion plant formed in the two examination areas was done in December during the step of maturity. Because the onions were directly compared depending on the soil type difference through factors such as size and integrity of red onion plant.

10. Results

Using GLOBE devices to analyse water properties-particularly fluorescent water-reveals significant characteristics that are crucial for defining the environmental context.

10. 1 The Data Obtained from Analysis Presents the following Key Parameters

	Characteristics	Value
First: Water properties data (fluorescence water) using GLOBE devices	Acidity (pH)	7.9
	Salinity (ppm)	753
	Conductivity (µs/cm)	1095

Table 1: GLOBE Devices for the Analysis of Water Properties

Acidity Value (pH): Since the measured pH is 7.9 the water sample is considered alkaline. Water's usefulness for different forms of agriculture and ecological balance might be impacted by its rather basic pH value.

Salinity: 753 parts per million is the salinity. This is an extremely important feature since it would effect the water's salinity, which again affects how well the water would be used for irrigation, as well as how it would impact the soil's health and plant growth.

- **Conductivity:** Conjecture of the electric conductivity of water is 1095 micro Siemens by centimeter (µs/cm). As expected, this measure will yield crucial information on the total concentration of the dissolved ions, which is required in determining the purity status of the water and its various consequences on agricultural systems.
- **First Description and Analysis:** The pH value of 7.9 is relatively basic. This may act differently in various biological aspects. Salinity at such a high value of 753 parts per million may affect plant growth and even soil conditions, mainly in agricultural practices that use irrigation. This conductivity value of 1095 µs/cm stipulates that there is an immense amount of ions present. It signifies the further requirements for checking water quality as well as its probable potential impact on agricultural yield.

This in-depth analysis of the characteristics of water really enlightens one on the status of the environment for which the implications might be used to point out possible impacts on farming practices and ecosystem health. For a thorough grasp of the relationship between soil characteristics and plant growth, more research and correlation may be required.

10.2 Soil Characteristics Data in the Two Regions

Soil characteristics tests conducted in these two designated study regions, Area 1 and Area 2, have produced data that will demonstrate the majority of criteria variances. Table 2: Data obtained in various formats, demonstrating variations in soil acidity (pH), water salinity (ppm), and soil conductivity (µs/cm). Area 1's soil had an approximate acidic character, as shown by its pH of 7.2. In addition, this soil's modest salinity of 680 ppm and conductivity of 962 µs/cm were noted. In contrast, the pH of the soil of Area 2 was a bit higher, 8.1, proving that it is more alkaline than that of Area 1. Measured at 751 ppm, the salinity levels of the soil in Area 2 fall under the category of moderate to high, which generally suggests a somewhat higher salinity level. Moreover, the electrical conductivity of the soil of this area was measured at 1064 µs/cm, showing higher electrical conductivity as compared to Area 1.

Values are very indicative of a clear distinction between the two regions on soil properties. Area 1 has a relatively lower salinity and electrical conductivity value, along with a slightly acidic soil type, whereas Area 2 is characterized by a soil type which is slightly alkaline with higher electrical conductivity and increased salinity level.

The difference in these soil properties from the two sites should be compared for possible implications on agricultural productivity in terms of the growth and quality of the red onion plant. Some of the key variables that highly impact on soil fertility, nutrient availability, and plants growth are pH, salinity and conductivity levels. Therefore, the results obtained have important implications for agricultural management and crop production techniques.

	Characteristics	Area1	Area2
Second: Soil Characteristics data in the two regions:	Acidity (pH)	7.2	8.1
	Salinity (ppm)	680	751
	Conductivity (µs/cm)	962	1064

Table 2: Soil Characteristics data in the two regions: 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).

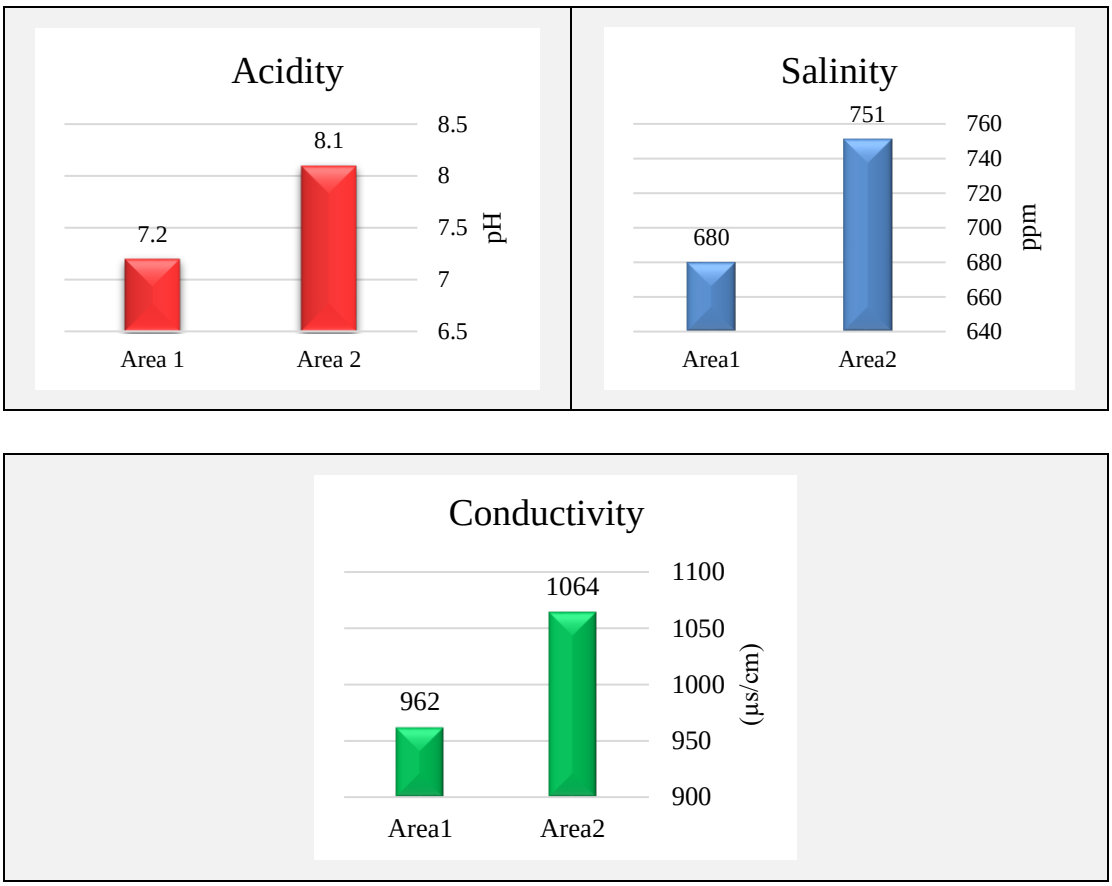


Figure 1: The evaluation of soil properties in the two defined regions (Area 1 and Area 2)

Area	(1)	(2)
Red onion quality in each region	Soil of suitable quality Shows better plant growth	Low quality soil Poor plant growth
Photo		

Figure 2 : Comparison of red onion production quality in two different regions showing the noticeable differences in the growth appearance of red onion plants in Area 1 and Area 2.

10.3 Third Observation - Appearance of Red Onion Plant

During the observation period of more than four months in the selected areas (Area 1 and Area 2), clear differences were observed in the appearance of the red onion plant, especially with regard to the size of the onions.

10.3.1 Area 1 (Farm 1)

- **Appearance:** We noted a very remarkable crop of red onion in Area 1. onions looked bigger in size and had better growth when compared to the onions harvested in Area 2.
- **Analysis:** Greater in size and of better growth implies that growing condition or some attribute of the soil is likely to be beneficial to the plant. The lack of small sizes may also be an indication of improved ability in the uptake of nutrients by the plant at a desirable rate.

10.3.2 Area 2 (Farm 2)

- Appearance: It was noted that the red onion plants in the monitored Area 2 were smaller in size and weaker in structure. Therefore, we conclude from this observation that the red onion plant was affected by the nature of the soil in Area 2, as this appeared clearly in the small size of the onion compared to the plants in Area 1.
- **Analysis:** Small size raises questions on whether it was the soil or environmental issue in affecting growth in plants. It demonstrates that there may be some sort of problem inhibiting complete nutrient absorption, the wrong or infertile type of soil, or even extreme moistening that is used during onion formation.

During the follow-up period, a comprehensive evaluation was carried out for the two areas: Area 1 and Area 2. The purpose of this selection was to measure several parameters related to the red onion plant, with a special focus on the soil type and its effect on the size (bulb). Observations were made for each area, samples were collected from each area and measurements were taken of the diameter of the red onion plant (bulb) in centimeters, which can be very useful in knowing the morphological characteristics of the studied plant. The results obtained are shown in Table 3 below.

Area	Area 1	Area 1
A sample from each site was taken to measure the bulb diameter of each plant		

Figure 3 : Taking measurements of samples of red onion plants from Area 1 and Area 2

Red onion plant samples Sample No.	Area 1 Diameter of Red onion plant (bulb) (cm)	Area 2 Diameter of Red onion plant (bulb) (cm)
1	26.5	17.5
2	30.4	16.8
3	28.9	17.4
4	25.1	17.6
5	29.7	18.2
Average	28.12	17.50

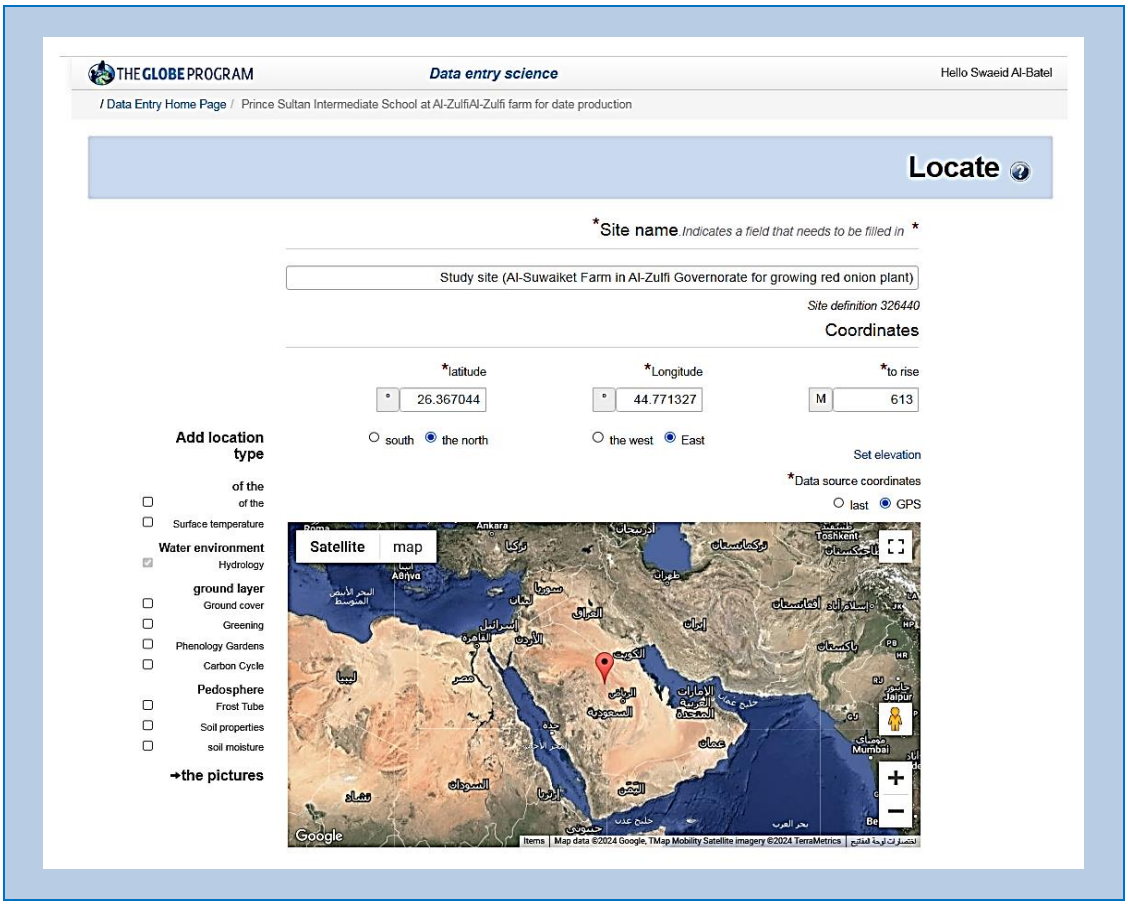
Table 3: shows the diameter of some samples of red onion (bulb) measured in centimeters in both Area 1 and Area 2. The average measurement of these samples selected from each region shows large differences in (bulb) size between the two sites.

Table 3 shows the bulb diameter recorded for a number of samples of red onion plants in centimeters in Area 1 and Area 2. Data on weights and diameter measurements (of the bulb) for the plants selected based on the average values in each zone also proved that there are indeed significant differences in the weight and size of the (bulb) between the two sites.

The average diameter of red onion plants (bulb) in Area 1 was 28.12 cm, on the other hand, the average diameter (bulb) of plants in Area 2 was much smaller at 17.50 cm, noting that five random samples were taken from each zone. This comparative analysis highlights the variation in bulb size and yield between the two research areas; therefore, there may be links between soil or physical environment that affect red onion plant growth.

These differences further emphasize the role of soil characteristics and other environmental factors that define the quality and yield of the red onion plant, thus affecting the direct relationship between yield changes and environment.

Such a detailed measurement and comparison allow gaining quite substantial information on the differences in particular features that a red onion plant exhibits depending on the soil environment, which, in its turn, contributes to the contingent of knowledge of the influence of the soil properties on the red onion plant quality.



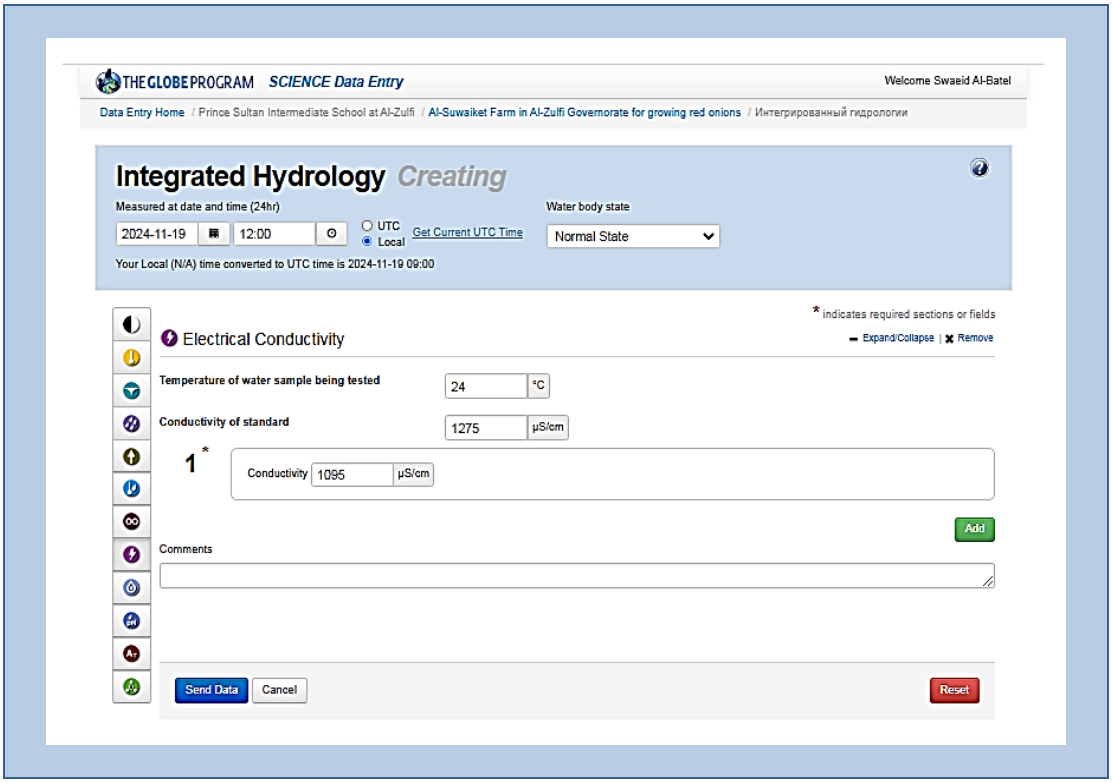


Figure 4: Data were entered and submitted to the program website through the website address:
www.globe.gov through the application DATA ENTRY.

10.4 Answering the Research Questions

The study questions were addressed in a methodical approach that aimed at identifying direct correlates between particular aspects of the studied soil and consequences for red onion plant yield and quality within Al-Zulfi City Saudi Arabia. To answer each sub-question, the study elaborated them as follows to uncover important implications concerning the interactions between the soil factors and the red onion plant crop.

- **Soil pH Impact on Nutrient Uptake:** The study carefully analyzed the extent to which different values of the soil pH affects nutrient and water uptake in the red onion plants. Thus, comparing one pH condition to the other, it was evident what direct effects extremes of pH had on nutrient solubility and therefore plant health.
- **To find out the precise impacts of changes in soil salinity on development patterns and physiological health:** The researchers (students) in collaboration with the laboratories of the Environment, Water and Agriculture Office located in the governorate conducted a comprehensive examination. This included determining the ability of red onion plants to adapt to different salt levels and how these differences affected the overall growth and health of the plants.

- **Influence of Soil Conductivity on red onion plant Development:** Conductivity of soil was identified by the study and its impact on the genre of developed red onion plant. Knowing the impact of different conductivity levels on the onion size and quality, the work pointed to a positive correlation between the productivity of red onion plants in the soil conductivity levels.
- **Interactions between Soil Attributes and Red onion Plant Productivity :**Descriptive and regression analysis was then used to determine the impact of these interactions between the soil attributes; pH, salinity, and conductivity, on the yield and Red onion plant quality. This work established these correlations and the overall effect of these soil characteristics on yield.
- **Optimal Soil Management Strategies:** By conducting the study, the essence of the variation in soil characteristics on red onion plant production was established, and suitable methods of soil management towards the reduction of these effects was also recommended. The research also made emphasis in determining which type of soil amendment as well as which kind of cultivation practice is most suitable in improving the condition of the soil to enable the growth of crops with maximum yield.

10.5 Verifying the Validity of the Research Hypotheses

- More information out there tends to point to a very close link between the quality of red onion plants and the soil conditions. There was a marked difference in the size and appearance of the onions as well as the root system when grown in two study areas with different pH, salinity, and conductivity.
- While these research and analyses highlight the independent effect of pH, salinity, and conductivity, they do not give the interaction effects. There is not sufficient data to analyze whether combination impacts are present.
- Specifically, the research does not experimentally compare the impact of tailored soil management strategies to other interventions. These conclusions underline the significance of knowledge about the soil and the possible change for improving the yield of the red onion plants. A more controlled experimental examination of the strategies in question would be required.

11. Discussion

The thorough examination of the gathered data has produced remarkable insights into the complex relationship between soil characteristics and the quality of red onion plant as a result. A strong correlation has been revealed by the thorough data analysis, which is best illustrated in Table 2, between variations in soil pH and the ensuing effects on the quality of the red onion plants. These results highlight the crucial role that soil pH plays in shaping the properties of red onion plants, which is particularly apparent given the different conditions that were found at Area 1 and Area 2.

The sharp rise in soil pH levels at Area 2, which reached a dangerously high 8.1, was especially noteworthy as it obviously degraded the onion's quality. This increase in soil pH was found to be substantially associated with detrimental

effects on red onion plants. These effects were particularly noticeable in the onion, which had a diameter of only 17.50 centimetres. These detrimental manifestations can be attributed to the soil's high pH levels, which hinder the red onion plant roots' capacity to efficiently absorb water. Therefore, this lesser capacity to hold water prevented the plants from taking in the nutrients contained in the water, with reduced measures significantly affecting appropriate essential nutrients required for optimal plant growth. However, it was also evident that the factor of increase in the level of soil pH is an indication of the advanced level of salts in the soil, which event is likely to affect the overall health and the growth of the red onion plants.

The survey also showed that the Area 1 climate was more conducive to the growth of red onion plants; hence, the onion quality was also better. Evidence of this was the big-sized onions were a characteristic of those plants. It may thus be attributed to the lower soil pH at this site leading to enhanced water uptake by the red onion plant roots, hence enhanced nutrient uptake, hence better onion and quality.

The relationships between the properties of soil and the observed effects on the quality of the red onion plants, especially the pH values in the soils described in this paper, proved the importance of soil management. In light of this understanding, the management and control of soil pH becomes a critical feature active in the enhancement of red onion plant farming methods, leading to healthy plants and quality yields.

12. Conclusion

Research into soil characteristics and their effects on red onion plant quality showed that soil pH, salinity, and electrical conductivity have very important effects on the growth and yield of red onion plants. A lower soil pH increases water and nutrient uptake, resulting in enhanced growth and larger bulb sizes. On the other hand, higher soil pH results in poor health of the plant and decreased root absorption capacity. The study, therefore, emphasizes the need for soil assessment prior to cultivation in order to optimize the conditions for red onion production. This will give farmers the opportunity to make informed decisions concerning amendments and cultivation techniques that will ensure quality and better yields of the crop. The study, however, indicated knowledge gaps in understanding the interaction of soil properties with each other. Further research is warranted to explore their combined impacts on red onion growth. The study contributes greatly to knowledge of agricultural practices, particularly in the good soil management of growing red onions.

13. Recommendations

13.1 Create an All-Inclusive Program for Farmer Education

The Al-Zulfi Agriculture Department and GLOBE should produce and distribute more guidelines informing farmers on compatible crops, ways of amending the soil and conducting soil testing. It is through the Agricultural Departments conducting such workshops that we shall disseminate these materials to the target growers.

13.2 Enhance Soil Testing Accessibility

Using mobile laboratories for soil analysis, which requires supervision from the Water, Environment and Agriculture Office in Zulfi Governorate, and investing in GLOBE environmental program devices and data. To ensure that all customers receive these services, these laboratories will move their services to productive fields, where they will conduct on-site analyses using GLOBE technology, and produce outputs on the best practices that should be adopted before planting to ensure greater production and better crop quality.

13.3 Guides on Crop Suitability and Regional Soil Mapping

To map the distribution of agricultural soil in the region, GLOBE data and studies conducted by the Water, Environment and Agriculture Office in Zulfi Governorate are being utilized. Detailed soil-based crop compatibility requirements are needed to ensure that farmers use appropriate cultivation methods, noting that red onion grows best in sandy clay soils as the sandy soil particles allow for increased bulb size.

13.4 Establishing a soil database in Al Zulfi Governorate

It is useful for the Water, Environment and Agriculture Office in Al Zulfi Governorate to establish an agricultural database that is continuously updated and that farmers in the governorate can refer to, helping them determine the requirements of each type of plant and the appropriate time for planting, and thus determining the appropriate time, place and environment for crop growth. Farmers can also be guided to benefit from the research and studies conducted by the GLOBE Global Program team related to field studies and research on soil, which helps them better understand the needs of the plant.

13.5 Customized Soil Management Guidelines

Prepare the programs and action based on the soils within the Al-Zulfi region. Provide farmers with clear specifications of how to assess the health of their soil, ranges of pH that are suitable for red onion plants (between 6.5 and 7.5) and which amendments to use for soil optimization.

13.6 Water Quality Regulation and Treatment

The basic standards for the quality of water used for irrigation were as specific as possible, with an emphasis on grading the salt content below 2000 ppm. To maintain the ideal soil condition, farmers were educated on the importance of testing water and soil from time to time, not overburdening one area with annual cultivation, and using modern irrigation methods that help reduce soil salinity.

13.7 Workshops for Education and Extension Service

Working to spread agricultural awareness and education through several means, including experts visiting farmers and investing in local radio and social media to educate farmers about modern irrigation methods, the type of soil suitable for each plant, and how to maintain the acidity balance of the soil in desert areas.

13.8 Governmental Support to Soil Improvement

In light of the Kingdom of Saudi Arabia's interest in encouraging self-sufficiency in food, work is being done to invest in this support by coordinating with government agencies to provide modern agricultural equipment and secure high-quality red onion seeds and suitable organic fertilizer at reduced prices, and inviting specialists to analyze water and examine soil periodically and coordinating with them to support correct practices that contribute to preserving soil and improving production.

13.9 Integration of Research and Contemporary Technologies

Encourage research articles about soil breakdown, precision farming, and cutting-edge soil modification technologies that incorporated contemporary methods and instruments, such as remote sensing, to assess soil health and enable farmers to make informed decisions.

13.10 Enforcement of Policies and Demonstration Farms

Displaying model farms that can be emulated in other countries whose climate is compatible with the climate of Al Zulfi Governorate, as well as holding exhibitions and implementing meetings through which successful local models that have been able to grow red onions well can be displayed and reviewing the methods and means used to achieve sustainable agriculture by taking care of soil quality and using correct irrigation methods in desert areas.

13.11 Platform for Constant Monitoring and Knowledge Exchange

Provide a central system that allows farmers, researchers, agricultural consultants, and extension workers to communicate with one another and, most importantly, to continuously monitor the state of the soil. It calls for the launch of new sharing events of research studies as a way of disseminating fresh ideas on how to embrace eco-friendliness in farming practices.

13.12 Collaboration with Local Research Institutions

Encouraging governmental and civil research centers and voluntary associations related to the agricultural sector to conduct studies in the field of soil and water characteristics to come up with recommendations that contribute to promoting sound agricultural practices in desert areas and clarifying the means that contribute to preserving soil quality and sustaining its production.

14. Limitation

Issues with a sufficient sample size, restrictions on weather and equipment data collecting, and the study's limited capacity to capture long-term impacts within the roughly five-month observation period are its main shortcomings. Due to the research's particular focus on soil qualities, it may be difficult to fully understand other significant variables, and the results could be impacted by uncontrollable variables and outside factors like socioeconomic circumstances. These are the constraints, including technical accessibility or regional specificity, which affect depth and universality due to a lack of resources. These should be acknowledged in order to guarantee cautious interpretations that show the necessity of taking these limitations into account when making conclusions and to conduct more research to address these constraints in greater detail**.**

15. Future Research Directions

- Longitudinal Studies: Large-scale research questions that span the several years may give a better understanding of how the character of the soil and red onion's plant development is changing over time. Long-term dynamics could possibly be enriched by studying how these interconnections evolve with different environmental states and seasons.
- Thorough Soil Analysis: Future studies should examine a greater variety of soil characteristics in addition to conductivity, salinity, and acidity. A more thorough understanding of their effects on red onion plant development might be possible with additional investigation into other factors such soil texture, microbial richness, and nutrient content**.**
- Various Environmental Factors: The benefit of going further beyond studying that set of environmental factors or parameters that may influence the condition of the soil as well as the further or is growth will be yielded through accounting for other forms of temperature fluctuations, amount of wind, and quantity of rainfall. This could be attributed to the fact that this research takes a comprehensive method that might help explain other queries related to production of red onion plant**.**
- Geographic Variability Studies: Expanding the study area to include different geographical locations with different soil types, weather conditions and cultivation methods would provide a comparative analysis. This comparative study would discover some factors that might be suitable for red onion cultivation. Expanding the areas under study would allow for a complete comparative analysis. A comparative study of some areas could provide an additional descriptor that would give recommendations on how to grow red onion in a particular area based on environmental factors.
- Technological Advancements: Enhancements of data acquisition would be easier by integrating modern technology in the soil sampling survey. These technologies comprise remote sensing techniques, monitoring technologies and soil mapping technologies. These instruments would be of immense help

in offering a much closer look at the manner in which the soil and productivity of crops are intimately related.Remote sensing techniques, real-time monitoring, and soil mapping technologies are a few examples of pro-serving technology. With such instruments, more rigorous assessment of the properties of the soil and impact these properties have on yields may be done.

- Understanding various multiple cropping practices and environmentally friendly techniques like crop turning and using organic manure and soil conservation practices may increase the growth quality of the soil as well as the physical growth rate of red onion plant. If more possibly holistic approaches were to be taken into consideration, other recommendations on how red onion plant could be produced in a considerate manner might be as well as studying various physical characteristics on the acerbation of soil productivity and plant. This comprehensive method might assist identify more variables influencing red onion plant yield**.**
- Exposing the growth medium to integrated farming practices such as crop rotation, organic soil amendments, and use of appropriate conservation practices were likely to enhance soil characteristics and thus the growth of red onion plant. Analyzing these comprehensive approaches could yield practical strategies for growing red onions in a sustainable manner.
- Knowledge Transfer and Community Involvement: It is proposed that involving farmers, agricultural experts, and local community people as research project participants may help to improve knowledge dissemination. The procedures that are pursued by engaging stakeholders in cooperative research projects may provide more usable findings.
- Assessment of the Economic Effects: Many more future researches may focus on assessing the financial returns that result from improving on the physical attributes of the soils for the growth of red onion plants. To farmer's and policy maker there may be of great benefit to understand which of the soil amendments and management tool is more economical or cost effective.
- Strategies for Adapting to Climate Change: More research should be conducted on the effects that environmental stresses and changing climate on red onion plant production as well as the soil. Subsequent research should strive to determine how climate variation affects the negativity enumerated above on agricultural production and how agriculturalists can adapt to the impacts**.**
- Interdisciplinary Approaches: Soil scientists, agronomists, climatologists or economists may thus work together in research activities to enhance a better appreciation of the integrated nature of an environment and soil resources and their further depiction in the enhancement of agricultural yield**.**

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Red onions, in all their varieties, have been an essential component of human food throughout the ages.