BUSITEMA UNIVERSITY
Pursuing Excellence

P.O. Box 236, Tororo, Uganda
Gen: +256 - 45 444 8838
Fax: +256 - 45 4436517
Email: info@adm.busitema.ac.ug

www.busitema.ac.ug

THE EFFECT OF DIFFERENT SOIL TYPES ON GERMINATION RATE AND EARLY SEEDLING DEVELOPMENT OF SOLANUM LYCOPERSICUM IN PALLISA TOWN COUNCIL, PALLISA DISTRICT

BY

ODELLE ABRAHAM JUSTINE

BU/UP/2021/1710

0781319180

odelleabraham@gmail.com

SUPERVISOR: MR. WAMBOGA EMMA

A RESEARCH REPORT SUBMITTED TO THE DEPARTMENT OF BIOLOGY IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF BACHELOR OF SCIENCE EDUCATION DEGREE OF BUSITEMA UNIVERSITY

JUNE, 202

DECLARATION

I Odelle Abraham Justine declare to my best of my knowledge that this dissertation is my original work and has not been submitted for any award to any university or tertiary institution.

Signature...............................

Date....18/09/2024....

APPROVAL

This project report has been submitted for examination with approval of my supervisor Mr. WAMBOGA EMMA

Signed.................................   Date 8/11/2024

DEDICATION

This project report is dedicated to my dear parents Mr. OMOROS STEPHEN and Mrs. NAWIRE JANET, my uncle Mr. ODELE JUSTINE and my sisters TIERI CHRISTINE SARAH and AKELLO FAITH for their love and unwavering support rendered to me in my academic journey to ensure that I succeed.

ACKNOWLEDGEMENT

I wish to extend my heartfelt appreciation to my dear lecturers and the laboratory technicians in the Biology Department of Busitema University my parents and siblings upon standing with me amidst several challenges in my academic endeavors.

I also extend my gratitude to my friends and classmates in the biology department Kalibata Dan, Onyango john, Omedel Wilson, Wopala Kevin, Khanakwa Rebecca Wamboka, Mpango Ashiraf, Isabirye Derrick, Kitayi Solomon, Mumbere Michael, Magomu Kenneth, Matsanga Joachim, Ngobi Andrew,Kiplimo Joshua, kamatei Evans, Kibet Daniel, Wodira Emmanuel,Nabaya Job Mazakis, Namasoko Jerald, Ajiambo Michah Padrah and Ngolobe Silas for having been of great support to me in various ways including discussions, encouragement and other sacrifices they made to ensure that I become a person of value.

Lastly, I extend my gratitude to my dear siblings and other relatives for their unconditional love shown to me throughout my academic journey.

DEFINITION OF TERMS

Term	**Meaning**
P^H	Potenz hydrogen
mm	millimeter
%	percentage
cm	centimeter

ABSTRACT

Tomato (Solanum lycopersicum) is a widely cultivated vegetable plant species and understanding the impact of different soil types on the germination rate and early seedling development in it is important in improving agricultural practices and ensuring sustainable yields (Smith, Johnson &Williams., 2021).

This study focused on investigating how different soil compositions influence the process of germination and the first growth stages of tomato. Three different soil types (sandy, clay and loams soil) were selected to assess their effects on germination rate and early seedling development of Solanum lycopersicum under controlled conditions. This experiment involved sowing tomato seeds in each soil composition followed by monitoring germination rates and early seedling growth parameters.

Results demonstrated significant variations in the germination rates and early seedling development across the various soil types. Sandy soil exhibited the highest germination rate (92.5%), followed by loam soil (87.5%) and clay soil had the lowest (57.2%) and loam soil supported highest seedling development in Solanum lycopersicum with sandy soil having the lowest growth rate of seedlings.

Table of Contents

Contents

CHAPTER ONE: INTRODUCTION

1.1Background

Solanum lycopersicum is a vegetable plant commonly known as tomato plant is a widely cultivated plant species which belongs to the Solanaceae family. This is a herbaceous plant and is available in different shapes, sizes and colors with different sugar levels (Thomas, 2014). Tomatoes have very high content of lycopene, which has several health benefits (Khan *et al*., 2021). Tomato is consumed freshly or processed and grown in almost every country of the world. The increase in the area of production and value has increased the economic importance of the crop worldwide (Khalifa *et al*., 2021).

At the global level, researchers have recognized the importance of soil quality and its impact on crop productivity including tomatoes (Seifu & Elias, 2018). Different soil types vary in their chemical, physical, and biological properties, which directly affect seed germination and seedling development (Lamichhane *et al*., 2018).

After China, India is the second largest producer of vegetables such as tomatoes in the world (Sah et al., 2022). Most of the vegetables like tomato are first sown in nursery beds and later transplanted manually on the ridges or on a well prepared seedbed (Muragi & Sajjan, 2019).

Within the African continent, agriculture serves as a source of live hood for most people and families in countries such as Nigeria where it is always grown both in rainy and dry season but need high light intensity and warm temperatures of not more than 21^{O}C (Chukwu, 2018). In the Eastern region of the African continent, Solanum lycopersicum is a key cash crop. Farmers in this region often face challenges such as limited access to quality seeds, unpredictable weather conditions, and poor soil fertility (Koza, 2022).

In Uganda, tomatoes are among the most important cash crops in the country. However, the Pallisa district, like many other regions of the country is characterized by many soil types mainly sandy, loamy and clay soils. These soil variations can significantly affect the growth and development of Solanum lycopersicum (Manfredi *et al*., 2019).

Germination is a critical stage in both the young stages and reproductive stages of plants marking the change from a dormant seed to an actively growing seedling (Longo *et al*., 2020). The germination rate is affected by various factors including soil type, moisture levels, temperature and nutrient availability (Follmer *et al*., 2021). Early seedling development is equally crucial as it sets the foundation for the plant's growth and productivity in the course of its life (Finch-Savage & Bassel, 2016).

Soil is the major medium for plant growth, providing physical support, water, nutrients and oxygen to the roots. Different soil types exhibit different characteristics such as structure, p^H levels, nutrient content and drainage capacity, which can all impact plant growth differently (Kalev & Toor, 2018). Understanding how different soil types influence the germination and early seedling development of Solanum lycopersicum can provide valuable information for optimizing cultivation practices and enhancing crop yields (Tolosa & Zhang, 2020).

Soil texture is the relative proportion of sand, silt and clay particles in the soil (Richer-de-Forges *et al*., 2022). Sandy soils have larger particles and hence offer good drainage but may struggle to retain water and nutrients. Clay soils have smaller particles with high water retention capacity but can be compacted. Loamy soil which contains a balanced mixture of sandy, clay and silt are considered the best for plant growth due to their optimal water drainage and nutrient retention properties. The texture of the soil can affect seed germination by determining the extent of water availability around the seed and root penetration during early seedling growth (Yu *et al*., 2024).

Soil p^H plays a key role in the nutrient availability of plants. Most plants prefer slightly acidic to neutral p^H levels for optimal growth. Extreme p^H levels can affect nutrient uptake by plants and disrupt various physiological processes such as imbibition essential for germination and early seedling development (Martínez-Ballesta *et al*., 2020). Focusing on how different p^H levels influence the performance of Solanum lycopersicum seeds can help identify suitable p^H ranges for maximizing germination rates and seedling vigor (Msimbira *et al*., 2022)

Besides physical properties like p^H and texture soil fertility in terms of nutrient availability also significantly impacts plant growth. Essential nutrients such as nitrogen, phosphorus, potassium, calcium, magnesium and micro nutrients play a vital role in various metabolic processes within plants different soil types varying their nutrient content and availability due to factors like organic matter content, microbial activity, weathering processes and previous agricultural practices. Imbalances or deficiencies in key nutrients can hinder germination success and early seedling establishment in Solanum lycopersicum (Bhattacharya, 2022)

Environmental factors influencing soil-plant relations such as temperature, light intensity, humidity levels and sand biotic interactions can interact with different soil types to influence plant growth outcomes (Xi, Bloor, & Chu, 2020). Temperature extremes can affect seed germination rates while availability can impact early seedling development through photosynthesis. Soil borne pathogens may also pose challenges to seedling health growth rate and vigor (Gupta & Kumar, 2020)

1.2 Problem statement

Tomatoes are one of the majorly grown vegetables in Pallisa district, eastern Uganda, primarily people cultivate them for the market but most farmers encounter difficulties in achieving optimal germination rates in tomato seeds and faster seedling development. These challenges not only affect the productivity but also highlight concerns regarding the soil types in which the farmers sow their tomato seeds since the soil type plays a vital role in determining successful farming outcomes (Brown & Green., 2019).

Since the germination process is a crucial stage that that sets the foundation for a healthy plant growth and yield, the poor germination rate and early seedling development faced by farmers in Pallisa need a deeper study into the effect of soil type on the initial stages of tomato growth so as to provide valuable insights which can empower local farmers to make the right decisions regarding soil management practices (Smith., 2020).

1.3 Research questions

What is the average time taken for Solanum lycopersicum seeds to germinate in each soil type?

How does the percentage of germination of Solanum lycopersicum seeds vary across different soil types?

What are the effects of different soil types on the early seedling development of solanum lycopersicum?

1.4 Objectives

1.41 General objective

The general aim was to assess the effect of different soil types on the germination rate and early seedling development in Solanum lycopersicum

1.42 Specific objectives

To compare the average time taken for Solanum lycopersicum seeds to germinate in each soil type.

To determine the percentage of germination of Solanum lycopersicum seeds across different soil types.

To compare the early seedling development of Solanum lycopersicum in different soil types.

1.5 Hypotheses

1.51 Null hypothesis

There is no effect of different soil types on germination rate and early seedling development in Solanum lycopersicum.

1.52 Alternative hypothesis

There is an effect of different soil types on the germination rate and early seedling development in Solanum lycopersicum

1.6 significance of the study

That study on the effect of different soil types on the germination rate and seedling development in Solanum lycopersicum is important in enabling the population to understand how different soil types influence the germination rate and early seedling development in Solanum lycopersicum can aid farmers and gardeners in selecting the most suitable soil type for optimal plant growth. This knowledge can contribute to improving crop yield and quality hence benefitting agricultural practices and food production.

1.7 Scope of the study

1.71 Content of the scope

This study aimed to investigate the effect of soil types on germination rate and seedling development in Solanum lycopersicum and suggest ways of maximizing tomato yields

1.72 Study area

The research was conducted in Pallisa town council (latitude 1^{0}09'60.00" N and longitude33^{0}42'59.99" E), Pallisa district. Three types of soil were chosen which included; loam, clay and sandy soil.

CHAPTER TWO: LITERATURE REVIEW

This literature review aims to explore the existing research on the topic assessing the effect of different soil types on the germination and early seedling development in Solanum lycopersicum. This review will provide an overview of relevant studies, methodologies employed and the outcomes in order to identify patterns, trends and knowledge gaps in this area of research. (Jerem & Mathews, 2021).

The germination rate and early seedling development are crucial stages in the growth of plants, as they directly impact overall crop productivity. Soil type is a significant factor influencing these processes as it can vary in its physical and chemical properties thus affecting nutrient availability water retention and aeration. Understanding the effect of different soil types on the germination rate and early seedling development is essential for effective crop management and maximizing agricultural production (Lamichhane *et al*., 2018).

2.1 Definition of soil

Soil can be defined as the uppermost layer of the earth's crust composed of mineral particles, organic matter, water and air. It is a vital natural resource that plays a crucial role in supporting life on earth. it is a complex mixture of minerals, organic matter, water, air and living organisms (Senesi & Loffredo, 2018). It serves a medium for plant growth, providing physical support, nutrients and water retention. The composition and characteristics of soil including its texture and structure greatly influence its suitability for various purposes such as agricultural activity, and engineering applications. Soil composition varies across different regions and can be classified into various types based on their texture such as clay, loam and sand. (Huang & Hartemink, 2020).

2.11 Clay soil

Clay soil has fine particles that are smaller than sand and silt particles. They have a diameter of less than 0.002mm that are tightly packed together, resulting in compactness and poor drainage. This type of soil holds water for extended periods which can be beneficial during dry spells. However, excessive moisture retention can also lead to water logged conditions making it challenging for plant roots to access oxygen (Pan *et al*., 2021).

The soil also can be sticky and heavy making it difficult to work with. It can cling to tools form clumps and dry to a hard surface. Conversely when clay soil is dry, it can become hard and compact making it challenging to dig and this therefore makes it to have the lowest rate of seed germination in tomatoes (Makhubelo, 2023).

However, clay soil contains high levels of nutrients to aid in proper plant growth than sandy soil due to its ability to retain nutrients. The particles have a large surface area allowing them to bind and hold nutrients more effectively. While it may hinder early seedling emergence due to its compactness, clay soil can provide steady nutrient availability once seedlings establish (G. Kaur *et al*., 2020).

2.12 Loam soil

This is the type of soil considered ideal for gardening and agriculture because it comprises a balanced mixture of clay, sand and silt particles, offering an ideal combination of water retention, drainage and nutrient availability. It is often referred to as the perfect or ideal for highest seed germination rate and seedling growth soil because it combines the best characteristics of different soil types. The composition of loam soil typically consists of approximately 40% silt, 40% sand and 20% clay, although the exact percentage may vary. This balanced combination allows the soil to retain moisture while still providing good drainage, ensuring that plants receive both water and oxygen. The sand particles in loam soil are large and coarse which helps in creating spaces for air and water movement, silt particles are medium sized and provide the soil with good fertility and moisture retention properties. Clay particles in the loam soil are small and fine which contribute to the soils ability to retain nutrients (Dubey & Verma., 2022).

The characteristics of loam soil make it suitable for a wide range of plants. It has a good water holding capacity preventing excessive water drainage and ensuring plants have access to moisture. At the same time, it drains well enough to avoid water logging, ensuring that plants don’t suffer from root rot. Loam soil supports optimal germination and early seedling development by providing essential nutrients and sufficient aeration (Dada *et al*., 2019).

2.13 Sandy soil.

Sandy soil has a high proportion of sand particles. It's characterized by its gritty texture and loose structure. It drains water quickly due its large particle size which leads to high permeability. It's often low in nutrients and organic matter making it less fertile compared to other soil types. Consists of larger coarse particles than clay and silt that create large air spaces and excellent drainage since water moves through the soil quickly which isssss important in preventing water logging and reducing the risk of root rot in plants. However, this can cause nutrients to leach out of the soil more rapidly. It does not retain water well and tends to be nutrient poor (Osman, 2018). They allow for easy root penetration and aeration, facilitating faster germination than in clay soil but slower than loam soil (Ben-Noah & Friedman., 2018).

2.2 Germination rate

Germination rate refers to the percentage of seeds that successfully sprout and develop into seedlings. It is influenced by various factors, including soil type, moisture levels, and temperature and seed quality. Different soil types can affect germination rate due to their water holding capacity, drainage and nutrient availability (Liao & Thomas, 2019).

Several studies have investigated the influence of soil types on germination rate of Solanum lycopersicum seeds. For instance, germination rates of tomato seeds in loamy, clay and sandy soils were compared and found that loamy soil significantly promoted germination compared to other soil types (Roberts., 2021). Conversely, another study reported higher germination rate in sandy soils due to their excellent drainage characteristics, which increase water availability to the seeds (Unkovich *et al*., 2020).

In order to determine the germination rate, multiple replicates of each soil type can be set up and allocated a specific number of seeds to each replicate. The seeds are evenly distributed within each replicate and placed in their respective soil types. The replicates are kept under the same environmental conditions, light, temperature and moisture. After a few days, the number of seeds which will germinate will be counted in each soil type and their percentage will be calculate (Javaid *et al*., 2018).

To determine the time taken for germination to occur in each soil type, seeds in each replicate are monitored and the date of germination for the seeds is recorded. The time taken for germination to occur can vary depending on the condition of seeds, soil type and environmental factors (Lamichhane *et al.*, 2018).

2.21 Average time taken for Solanum lycopersicum seeds to germinate in each soil type.

Tomato seeds are commonly used for germination studies due to their availability, ease of handling and relatively short germination period and the time taken for tomato seeds to germinate can vary depending on various factors including soil type.

Clay soil is known for its fine particles and high water retention capacity and while it may have good moisture retention, it can also lead to poor aeration due to its compact nature, this affects the oxygen supply to the seeds and hinder germination. The dense structure of clay soil can also make it challenging for young roots to penetrate and establish themselves.

Loam soil is considered ideal for plant growth as it strikes a balance between sand, silt and clay particles. It offers good drainage while retaining sufficient moisture for seed germination. The well aerated structure of loam soil promotes healthy root development and supports optimal seedling growth.

Sandy soil is characterized by its large particle size and excellent drainage properties and while it allows for rapid water infiltration and good aeration, it tends to dry out quickly due to low water retention capacity. This fast draining nature can lead to inconsistent moisture levels that may impact germination rates.

A study by Smith *et al*., (2018) compared the average time taken for tomato seeds to germinate in clay, loam and sandy soil over a four-week period. The results indicated that tomato seeds planted in loam soil exhibited the fastest germination rates, followed by sandy and then clay.

Additionally, a meta-analysis conducted by Brown *et al*., (2020) synthesized data from multiple studies on seed germination across various soil types. The analysis revealed that while clay soils delayed initial germination compared to loam and sandy soils, they ultimately supported robust plant growth once seeds sprouted.

2.22 Percentage of germination of Solanum lycopersicum seeds across different soil types.

Germination is a critical stage in the life cycle of plants, including tomatoes. The type of soil in which seeds are planted can significantly impact germination rates.

Loam soil is a balanced mixture of sand, silt and clay, providing good drainage and nutrient retention. Studies have shown that tomato seeds planted in loam soil tend to have high germination rates due to its optimal texture and water retention capacity. A research by Smith *et al*., (2018) reported a germination rate of 85% for tomato seeds in loam soil.

Clay soil is characterized by small particles that compact easily, leading to poor drainage and aeration. Tomato seeds planted in clay soil may experience lower germination to loam or sandy soil. A study conducted by Johnson (2019) found that tomato seeds in clay soil had a germination rate of 60%.

Sandy soil has large particles that allow for good drainage but may struggle with water retention and nutrient availability. Germination rates of tomato seeds in sandy soil can vary depending on irrigation practices and nutrient supplementation. Research by Brown and Lee (2019) indicated a germination rate of 75% for tomato seeds in sandy soil.

2.3 Seedling development

Seedling development is the process by which a germinated seed grows into a young plant. It involves the formation of roots, stems, and leaves as well as the uptake of nutrients and water from the soil. Soil type can impact seedling development by influencing root growth, nutrient availability and water retention (Grossnickle & MacDonald, 2018).

Seedlings after germination can be monitored in terms of growth patterns, leaf colour, stem strength, and overall health. Any abnormalities which can hinder proper seedling development can be identified and once seedlings reach a specific growth stage such as when the first true leaves appear they are assessed in terms of health and Seedling development which can be determined using the following parameters (Tong *et al*., 2021).

Seedling height. Seedling height is measured as an indicator of growth. This can be done by using a ruler or measuring tape to determine the distance from the base of the seedling to the tip of the main stem. Measurements can be taken every five days after the first week of germination to track the growth progress over time (Grossnickle & MacDonald, 2018). Several studies have investigated the relationship between soil type and tomato seedling height. For instance, Smith and Jones (2018) found that tomato seedlings grown in loam soil exhibited significantly greater height compared to those grown in clay or sandy soil. Conversely Brown et al., (2020) reported no significant differences in seedling height among the different soil types.

Number of leaves. This is an important parameter to assess the development and vigor of seedlings. It is determined by visually counting the total number of leaves on each seedling by carefully observing the plant and counting individual leaves, taking care not to count any damaged or partially grown leaves (Perez-Harguindeguy *et al*., 2016). Research by Johnson (2019) demonstrated that tomato plants grown in sandy soil exhibited a higher number of leaves compared to those in clay soil. In contrast, Garcia and Martinez (2017) reported no significant differences in leaf number between loam and clay soils.

Branch development. Branch development refers to the growth and branching pattern of the main stem and secondary stems. This can be determined by visually inspecting the plant and counting the number of branches or by measuring the length of individual branches. If the branches are not easily distinguished, they can be marked during data collection to avoid confusion. A study by Lee *et al.* (2021) revealed that tomato plants grown in clay soil exhibited better branch development compared to those in loam or sandy soils.

CHAPTER THREE: METHODOLOGY

3.1 Study site

The was conducted in Odwarat village, Westward, Pallisa town council, Pallisa district in the month of June, 2024 on a 5mx3m nursery bed consisting of individual nursery beds of loam, clay and sandy soil each consisting of 5 experimental units each consisting of 50 seeds hence allowing for replication across different soil types of loam, clay and sandy soil.

3.2 Research design

The research design for investigating the effect of different soil types on the germination rate and early seedling development in Solanum lycopersicum involved an experimental approach (Bellino *et al*., 2018).

This design was chosen to establish a cause-and-effect relationship between the independent variable which is the different soil types and the dependent variables which are the germination rate and early seedling development of Solanum lycopersicum. By using an experimental design, potential confounding variables were controlled to ensure that any observed differences in germination rate and seedling development would be as a result of the soil types (Kaur *et al*., 2017).

Fifteen experimental groups were created and every five corresponded to one soil type that was loam, clay and sandy soil. The five groups of each soil type containing fifty seeds were labeled as A1, A2, A3, A4, and A5 for loam soil, B1, B2, B3, B4, and B5 for clay soil and C1, C2, C3, C4 and C5 for sandy soil. The soil types varied in key characteristics such as nutrient content, p^H level, and soil texture and drainage capacity. (Coyle *et al*., 2019).

For the selection of Solanum lycopersicum seeds, I obtained amazon tomato seeds from a seed supplier to ensure the seeds quality and genetic uniformity. It was essential to use seeds from the same plant variety to minimize genetic variability and ensure that any observed difference in germination rate and early seedling development could be attributed to soil type rather than genetic factors (Lamichhane *et al*., 2018) and to create a representative sample of seeds, a random sampling method was used, where seeds were selected randomly from a larger population of seeds. Similarly, for the selection of different soil types, a range of soil types that are relevant to the growth of Solanum lycopersicum such as loam, clay and sandy soil were considered. This involved collecting soil from different geographical locations, agricultural sites, or experimental plots to capture the variability in soil characteristics such as nutrient content, p^H level and texture (de Oliveira *et al.*, 2018). The Solanum lycopersicum seeds were assigned to each soil type group to minimize biases and to ensure that each seed had an equal chance of being exposed to different soil conditions. This randomization helped to increase the generalizability of the results and enhance validity of the findings.(Beets *et al*., 2020)

Throughout the experimental period, germination rate and early seedling development of Solanum lycopersicum were closely monitored in each soil type group. By systematically varying the independent variable (soil type) and measuring the corresponding changes in the dependent variable (germination rate and seedling development), the impact of different soil types on the germination rate and seedling development in Solanum lycopersicum were established *(*Bellino *et al.,* 2018).

The three soil samples of loam, clay and sandy before sowing seeds

ss**The three soil samples after sowing of seeds in the nursery bed**

3.3 Data collection

The data was collected during the experiment provided valuable insights into how soil type influences the germination rate and early seedling development of Solanum lycopersicum plants.

Throughout this research study, I collected data on various parameters related to germination rate and early seedling development from the time of sowing seeds in the nursery bed to the 25^{th} day after germination. These included;

3.41 Number of seeds that germinated in each soil type group

Multiple replicates of each soil type were set up and a specific number of seeds was allocated to each replicate. The seeds were evenly distributed within each replicate. The replicates were kept under the same environmental conditions, light, temperature and moisture. After a few days, the number of seeds which germinated was determined in each soil type and their percentage was calculated as $\frac{Nunber\ of\ seeds\ that\ will\ germinate}{Numberof\ seeds\ sown} * 100\%$

3.42 Time taken for germination to occur

To determine the time taken for germination to occur in each soil type, seeds in each replicate were monitored and the date of germination for the seeds was recorded. The time taken for germination to occur varied depending on the conditions of the soil type such as temperature, p^H etc. (Lamichhane et al., 2018).

3.43 Percentage of seeds which successfully developed into healthy seedlings.

Seedlings after germination were monitored in terms of growth patterns, leaf colour, stem strength, and overall health. Any abnormalities which can hindered proper seedling development were identified and once seedlings reached a specific growth stage such as when the first true leaves appear they were assessed in terms of health and vigor. The seeds considered healthy in each soil type were counted and their percentage was determined based on the total number of seeds sowed in each group.

In addition to germination rate, data on early seedling development of Solanum lycopersicum was collected in each soil type group. This involved;

3.44 Height of seedlings

Seedling height was measured as an indicator of growth. This was done by using a ruler or measuring tape to determine the distance from the base of the seedling to the tip of the main stem. Measurements were taken every five days after the first week of germination to track the growth progress over time.

3.45 Number of leaves

This is an important parameter to assess the development and vigor of seedlings. It was determined by visually counting the total number of leaves on each seedling by carefully observing the plant and counting individual leaves, taking care not to count any damaged or partially grown leaves.

By systematically collecting data on these variables, the overall growth and performance of Solanum lycopersicum was evaluated.

To ensure accuracy and reliability of the data collected, standardized methods and tools for measurement were employed. This included using rulers and measuring tapes to record height and dimensions of seedlings as well as visual inspection to assess the overall health and vigor of the seedlings.

Collection occurred at regular intervals of five days after the first week of germination throughout the experimental period of one month to capture the dynamic changes in germination rate and early seedling development. By collecting data at multiple time points, the progress of Solanum lycopersicum plants in each soil type group was tracked.

CHAPTER FOUR: RESULTS

4.1 Results and Data analysis

After collecting data on the germination rate and early seedling development in Solanum lycopersicum for each soil type, it was organized in tables and analyzed in the following ways;

Descriptive statistics were calculated to summarize the data for each soil type (Chaney *et al*., 2019) This will included measures such as mean and range. These statistics provided an over view of the central tendencies, and distribution of data

In graphical representation, appropriate graphs were created to visualize the data. For germination rate, a bar graph was used to show the number of germinated seeds for each soil type and the same was done for early seedling development.

Interpretation of the findings of the study were discussed in context of the research questions and existing literature. The effects of different soil types on germination rate and early seedling development were explained and significant differences observed were highlighted.

4.11 Time taken for germination to occur

Time taken for germination to occur in every soil sample was determined by continuously checking on the number of seeds that germinated in each experimental unit of every soil sample daily until the seeds stopped germinating any more. The number of days taken for all seeds to germinate in each experimental unit was recorded as seen in the tables below. Seeds sown in clay soil took the most number of days to germinate, seeds sown in loam soil took a moderate number of days and seeds sown in sandy soil took the least number of days to germinate. The number of days taken for germination of all seeds to take place in every experimental unit were tabulated as seen below

Table 1

Experimental unit in loam soil sample	Number of days taken for seeds to germinate
A1	11
A2	11
A3	13
A4	10
A5	12

Average number of days taken for seeds to germinate = 11

Table 2

Experimental unit in clay soil sample	Number of days taken for seeds to germinate
B1	13
B2	15
B3	15
B4	15
B5	14

Average number of days taken for seeds to germinate = 14

Table 3

Experimental unit in sandy soil sample	Number of days taken for seeds to germinate
C1	09
C2	11
C3	09
C4	09
C5	10

Average number of days taken for seeds to germinate = 10

Highest average number of days taken for seeds to germinate found in clay soil = 14 days

Lowest average number of days taken for seeds to germinate found in sandy soil=10 days.

4.12 Percentage of seeds that germinated in each soil type group

The number of seeds that germinated in each soil type was determined after all the seeds had germinated in each soil sample. This was done by directly counting the number of seedlings in each of the five experimental units of A1, A2, A3, A4 and A5 for loam soil, B1, B2, B3, B4 and B5 for clay soil and C1, C2, C3, C4 and C5 for sandy soil and these were converted to percentages. The results showed that sandy soil had the highest percentage of germination, loam soil had the moderate percentage and clay soil had the lowest germination percentage.

Table 4

Experimental unit in loam soil sample	Germinated seeds out of 50 seeds sown	Percentage germination (%)
A1	37	74
A2	41	82
A3	43	86
A4	40	80
A5	47	94

Average percentage germination in loam soil = 83.2%

Table 5

Experimental unit in clay soil sample	Germinated seeds out of 50 seeds sown	Percentage germination (%)
B1	22	44
B2	19	38
B3	28	56
B4	25	50
B5	18	36

Average percentage germination in clay soil = 44.8%

Table 6

Experimental unit in sandy soil sample	Germinated seeds out of 50 seeds sown	Percentage germination (%)
C1	48	96
C2	46	92
C3	47	94
C4	45	90
C5	46	92

Average percentage germination in sandy soil = 92.8%

Highest germination percentage found in sandy soil = 92.8%

Lowest germination percentage found in clay soil = 44.8%

Germination percentage range = Highest percentage –Lowest percentage

= (92.8-44.8) % = 48%

4.13 Percentage of seedlings which successfully developed into healthy seedlings

The number of the seedlings that germinated were determined and out of them some did not fully develop into healthy seedlings. Those which developed into healthy seedlings in terms of good growth pattern, green leaf colour and having strong stems were counted on day 25 after germination and recorded for each experimental unit of the soil samples in tables. Loam soil had the highest percentage of seeds which successfully developed into healthy seedlings, followed by clay soil and sandy soil had the least percentage.

Table 7

Experimental unit in loam soil sample	Number of seeds that germinated out of 50 seeds sown	Number of seeds which developed into healthy seedlings	Percentage of seeds that developed into healthy seedlings (%)
A1	37	35	95
A2	41	38	93
A3	43	38	88
A4	40	37	93
A5	47	41	87

Average percentage of seeds that developed into healthy seedlings = 91.2

Table 8

Experimental unit in clay soil sample	Number of seeds that germinated out of the 50 seeds sown	Number of seeds which developed into healthy seedlings	Percentage of seeds that developed into healthy seedlings (&)
B1	22	18	81
B2	19	17	89
B3	28	24	86
B4	25	23	92
B5	18	17	94

Average percentage of seeds that developed into healthy seedlings = 88.4

Table 9

Experimental unit in sandy soil sample	Number of seeds that germinated out of 50 seeds sown	Number of seeds which developed into healthy seedlings	Percentage of seeds that developed into healthy seedlings (%)
C1	48	32	67
C2	46	35	76
C3	47	33	70
C4	45	33	73
C5	46	30	65

Average percentage of seeds that developed into healthy seedlings = 70.2%

Highest percentage of seeds that developed into healthy seedlings found in loam soil = 91.2%

Lowest percentage of seeds that developed into healthy seedlings found in sandy soil = 70.2%

4.14 Height of seedlings

The average height of seedlings was monitored and measured in all the five experimental units of each soil sample and recorded. Loam soil had the highest average height of seedlings, followed by clay soil and sandy soil had the lowest average height of seedlings.

Table 10

Experimental unit in loam soil sample	Average height of seedlings in the experimental unit (cm)
A1	6.4
A2	5.9
A3	6.6
A4	6.9
A5	6.1

Average height of seedlings in the loam soil sample = 6.4cm

Table 11

Experimental unit in clay soil sample	Average height of seedlings in the experimental unit (cm)
B1	5.2
B2	5.6
B3	5.1
B4	5.4
B5	5.1

Average height of seedlings in the clay soil sample = 5.3cm

Table 12

Experimental unit in sandy soil sample	Average height of seedlings in the experimental unit (cm)
C1	3.8
C2	4.0
C3	4.2
C4	3.9
C5	4.0

Average height of seedlings in the sandy soil sample = 4.0cm

Highest average height found in loam soil = 6.4cm

Lowest average height found in sandy soil = 4.o cm

4.15 Number of leaves

Average number of leaves in each soil sample was determined by counting the number of leaves on the seedlings 25 days after germination and the following results were obtained with seedlings planted in loam soil having the highest number of leaves followed by clay soil and sandy soil with the least number.

Table 13

Experimental unit in loam soil sample	Average number of leaves in the experimental unit
A1	5
A2	5
A3	5
A4	6
A5	5

Average number of leaves in the loam soil sample = 5

Table 14

Experimental units in clay soil sample	Average number of leaves
B1	4
B2	4
B3	4
B4	4
B5	5

Average number of leaves in the clay soil sample = 4

Table 15

Experimental units in sandy soil sample	Average number of leaves
C1	4
C2	3
C3	4
C4	3
C5	4

Average number of leaves in the sandy soil sample = 4

Highest average number of leaves found in loam soil sample = 5 leaves

Lowest average number of leaves found in clay and sandy soil = 4 leaves

4.16 Bar graphs

Figure 1

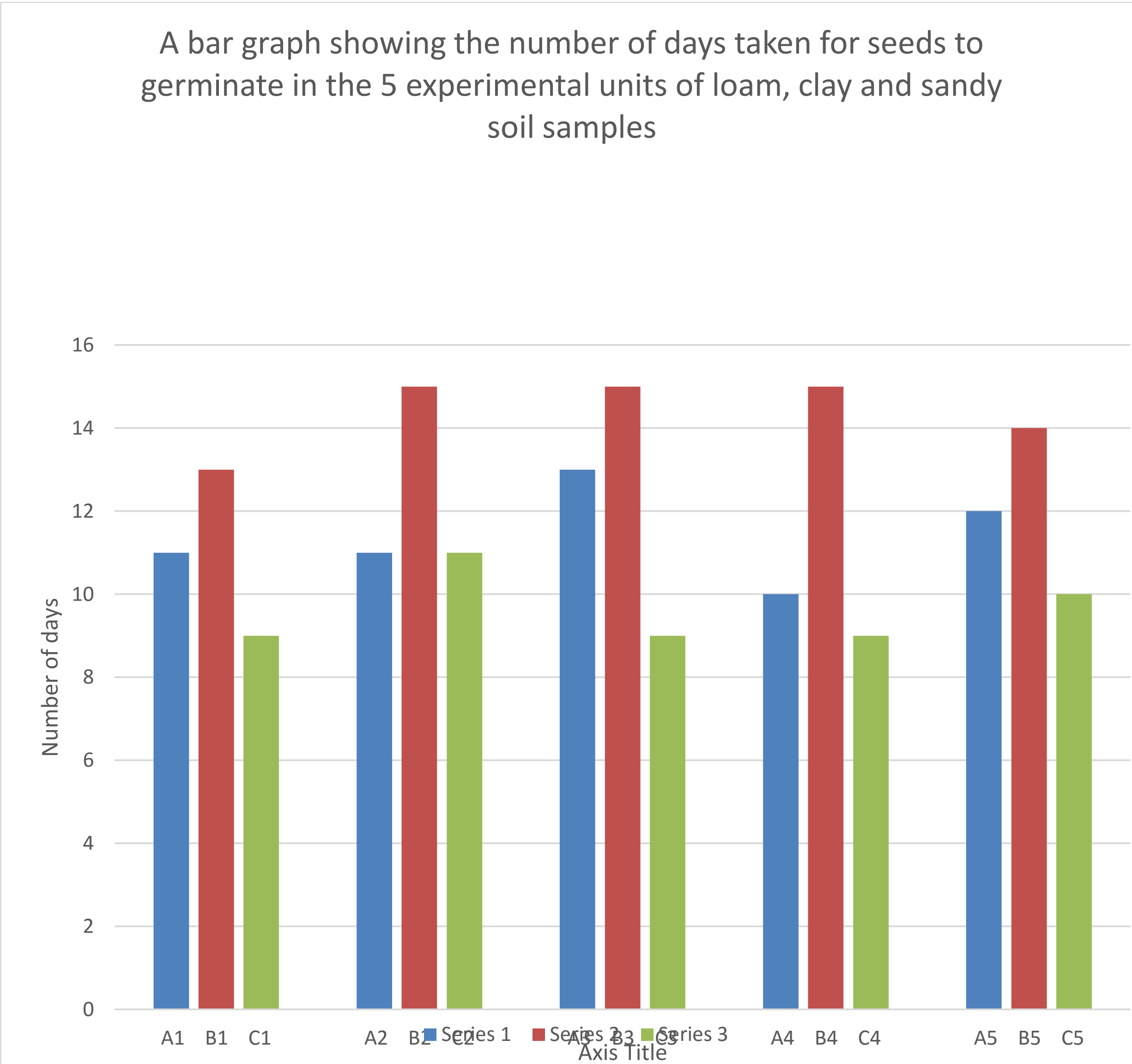


Figure 2

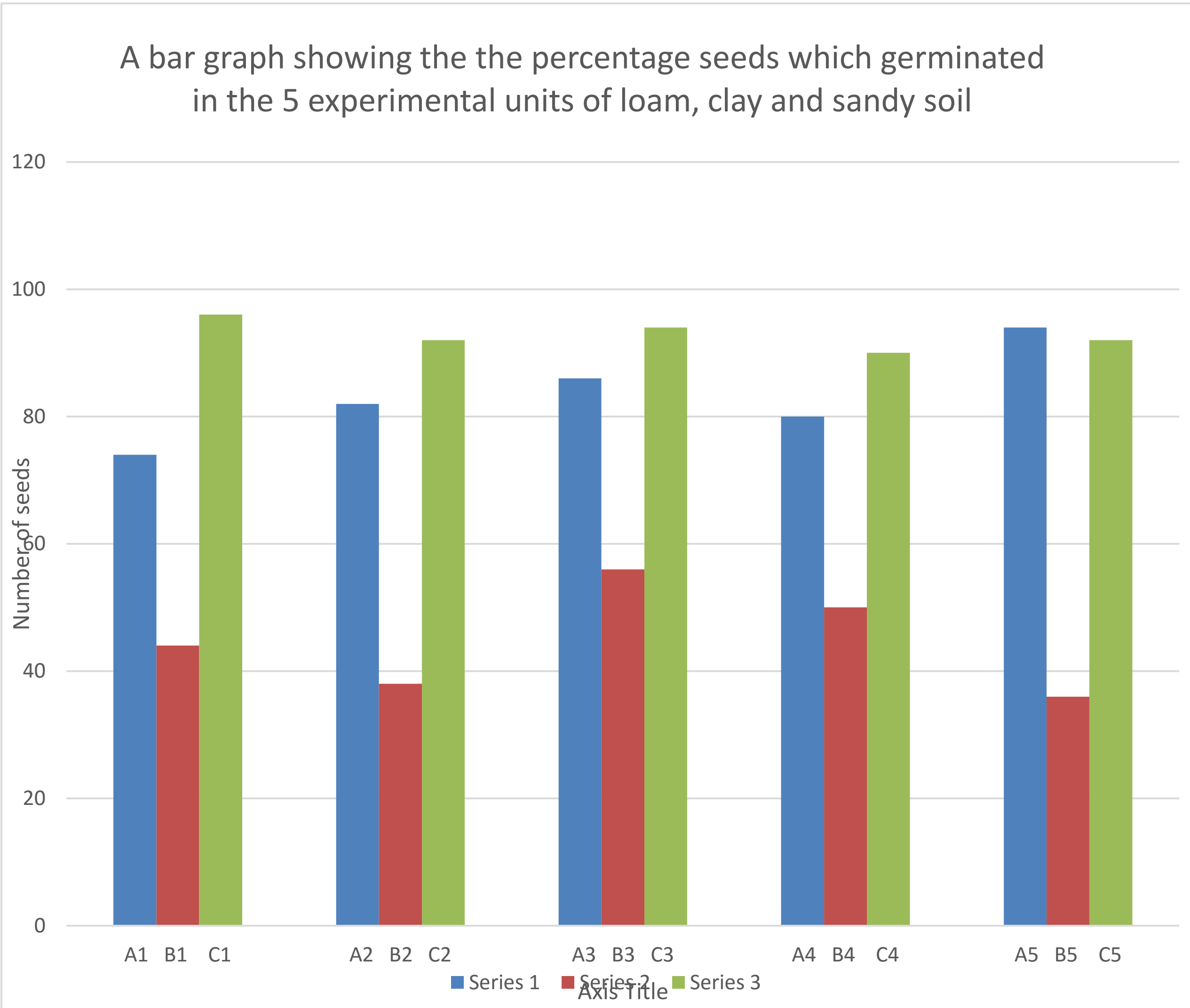
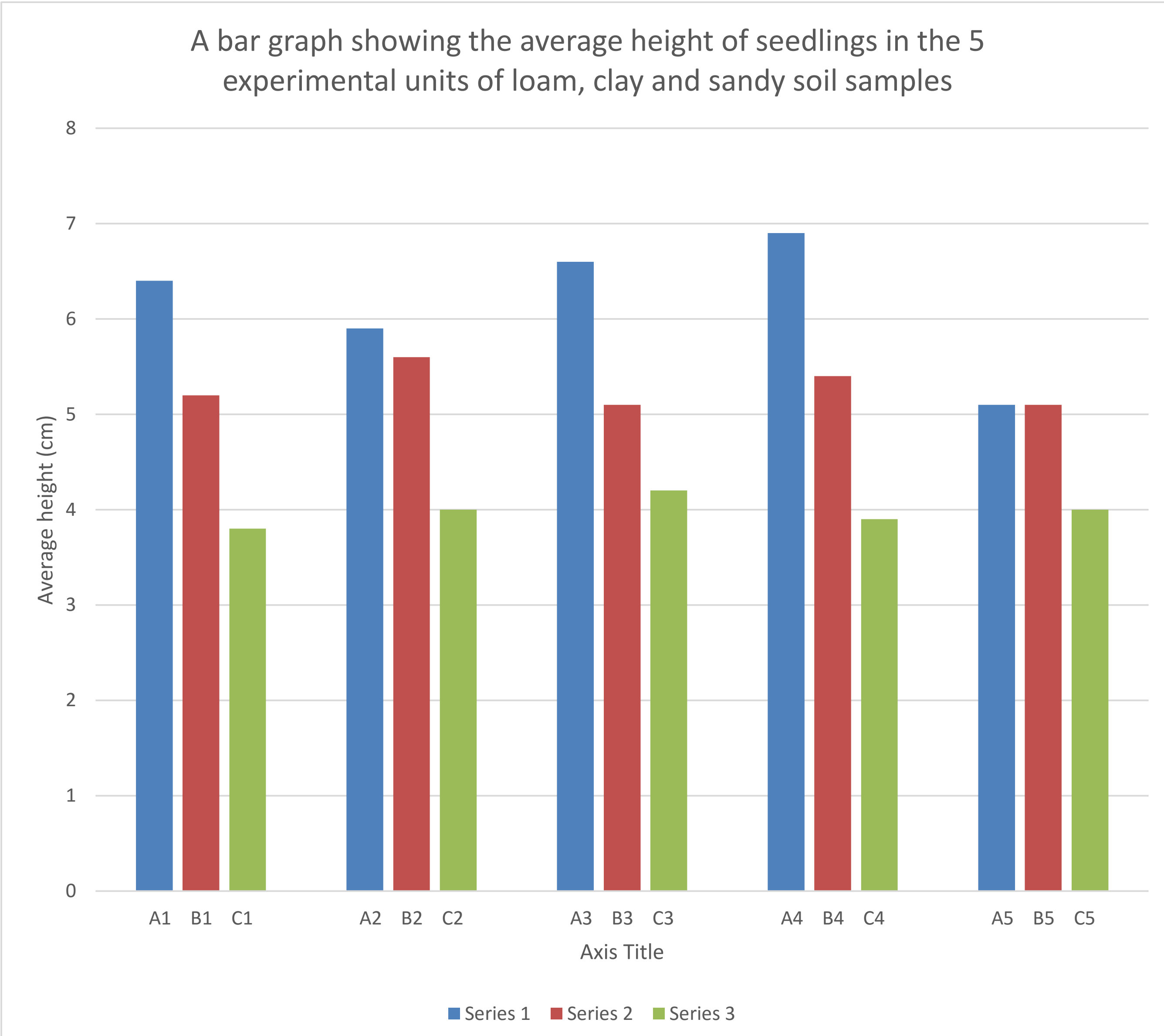
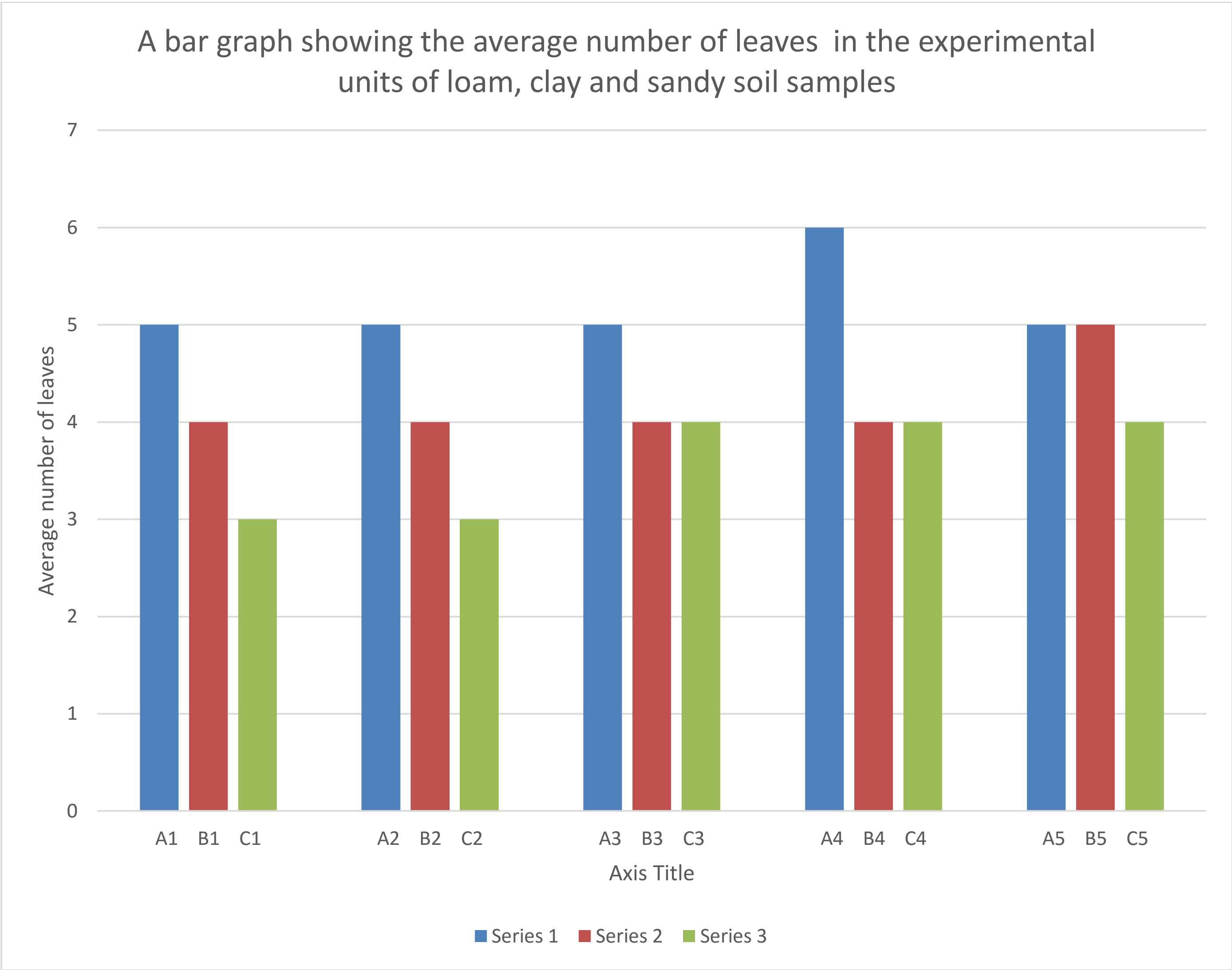

A bar graph showing the the percentage seeds which germinated in the 5 experimental units of loam, clay and sandy soil
120
100
80
60
40
20
0
Number of seeds
A1 B1 C1
A2 B2 C2
A3 B3 C3
A4 B4 C4
A5 B5 C5
Axis Title
Series 1
Series 2
Series 3

Figure 3



A bar graph showing the average height of seedlings in the 5 experimental units of loam, clay and sandy soil samples
8
7
6
5
4
3
2
1
0
Average height (cm)
A1 B1 C1
A2 B2 C2
A3 B3 C3
A4 B4 C4
A5 B5 C5
Axis Title
Series 1
Series 2
Series 3

Figure 4



A bar graph showing the average number of leaves in the experimental units of loam, clay and sandy soil samples
Average number of leaves
0
1
2
3
4
5
6
7
A1 B1 C1
A2 B2 C2
A3 B3 C3
A4 B4 C4
A5 B5 C5
Axis Title
Series 1
Series 2
Series 3

CHAPTER FIVE: DISCUSSION OF RESULTS

5.1 Percentage germination.

The data pertaining to germination percentage (table 1, 2 and 3) revealed that different soil types affected the germination of the tomato seeds differently such that out of the 50 seeds sown in each experimental unit in every soil sample, it was observed that sandy soil had the highest percentage germination (92.8%), followed by loam soil (83.2%) and clay soil had the least (44.8%). This is because the particles in sandy soil are large with plenty of space allowing for good drainage and aeration. This enhances access to oxygen which is essential for seed germination and also water and nutrients to flow through it quickly to effect faster germination. These results are in agreement with the study by Zhou *et al*., (2019).

While sandy soil drains well, it may struggle to retain moisture. For tomato seeds, excessive moisture can lead to rot and prevent germination. Loam soil strikes a balance between drainage and moisture retention, providing optimal conditions for seed germination (Bonanomi *et al*. 2018).

Clay soil has small particles that can lead to compacted soil, limiting oxygen availability and root penetration. This compacted nature can hinder seed germination. This agrees with research done by Miedema *et al.,* (2022) which emphasizes that soil compaction can negatively impact seed germination.

Clay soil had the lowest percentage germination because of its poor aeration, water logging and an impervious layer formed by the compact mass structure.

5.2 Early seedling growth.

Vegetable characteristics of Solanum lycopersicum varied in different soil types. Tomato plants grown in loam soil were faster in growth than plants grown in clay and sandy soil and tomato plants grown in sandy soil were slower to grow during growing stages (height and number of leaves). Tomato plants grown in clay were better in growth and number of leaves than tomatoes grown in sandy soil.

The experiment lasted for about 40 days. The tomato plants that grew in loam soil had the highest growth and number of leaves. When comparing the clay soil with the sandy soil in terms of height and number of leaves, the clay soil was better than the sandy soil because in clay soil, the particles are smaller, more negatively charged and have a larger specific surface area, providing more sites for cations to bind and these characteristics contribute to the greater ability of clay soils to hold and exchange cations, which is beneficial for soil fertility and nutrient availability to plants. These results disagree with results obtained by (Najia Shwerif, *et al.*, 2020) who observed a higher growth rate in sandy soil than clay soil but agree with the results got by Unkovich.,(2020) because clay soil contains a higher amount of nutrients, especially nitrogen which enhances vegetative growth. Loam soil had the greatest impact on seedling growth with the greatest height of seedlings and the highest number of leaves in seedlings because it contains the largest amount of nutrients.

The relatively loose structure of loam soil allows for easy root penetration and growth. A study by Ostonen *et al*., (2021) in plant rooting depth and microbial growth observed that plants in loamy soil tended to develop deeper roots systems, aiding in better nutrient uptake and overall plant growth.

Clay soil with its small particles tend to have higher nutrient content than sandy soil and retains moisture well. However, its dense structure can hinder root growth and root availability. Also compaction in clay soil may hinder proper aeration and drainage which can impact seedling growth. Martin *et al*., (2023) in "Abiotic stress and Biotic interactions: A case study of tomato growth in clay, loam and sandy soil" found that clay soils restricted root growth due to compaction.

5.3 Conclusion.

Tomato germination rate and seedling development differ in environmental requirements such as soil types, temperature etc. Solanum lycopersicum is one of the vegetables which can grow in various soil types but requires a suitable type and composition for its optimum growth and this makes some farmers to consider it as undesirable for cultivation although others on the contrary consider it a desirable vegetable.

Improving poor soil so as to improve nutrients and thus increase the productivity of tomatoes in Pallisa town council are important strategies that should be taken as tomatoes are important vegetables for consumption.

5.4 Recommendations

I recommend that farmers should consider sowing their seeds in sandy soil so as to obtain high germination rates and then quickly transplant them to gardens containing loam soil which are the most ideal for the growth of the tomato plants.

I also recommend that more researches be conducted on soil properties such as pH, temperature, light intensity and others which also contribute to the differences in the impact of soil types on germination rate and early seedling development in Solanum lycopersicum so as to maximize tomato yield.

5.5 References

Bareke, T. (2018). Biology of seed development and germination physiology. *Adv. Plants Agric. Res, 8*(4), 336-346.

Beets, M. W., Weaver, R. G., Ioannidis, J. P., Geraci, M., Brazendale, K., Decker, L., . . . Jago, R. (2020). Identification and evaluation of risk of generalizability biases in pilot versus efficacy/effectiveness trials: a systematic review and meta-analysis. *International Journal of Behavioral Nutrition and Physical Activity, 17*, 1-20.

Bellino, A., Lofrano, G., Carotenuto, M., Libralato, G., & Baldantoni, D. (2018). Antibiotic effects on seed germination and root development of tomato (Solanum lycopersicum L.). *Ecotoxicology and environmental safety, 148*, 135-141.

Ben-Noah, I., & Friedman, S. P. (2018). Review and evaluation of root respiration and of natural and agricultural processes of soil aeration. *Vadose Zone Journal, 17*(1), 1-47.

Bhattacharya, A. (2022). Effect of low-temperature stress on germination, growth, and phenology of plants: A review. *Physiological processes in plants under low temperature stress*, 1-106.

Bruand, A. Assembly 4 Physical properties of tropical sandy soils".

Bwambale, E., Abagale, F. K., & Anornu, G. K. (2023). Model-based smart irrigation control strategy and its effect on water use efficiency in tomato production. *Cogent Engineering, 10*(2), 2259217.

Casals, J., Martí, M., Rull, A., & Pons, C. (2021). Sustainable transfer of tomato landraces to modern cropping systems: the effects of environmental conditions and management practices on long-shelf-life tomatoes. *Agronomy, 11*(3), 533.

Chakma, P., Hossain, M. M., & Rabbani, M. G. (2019). Effects of salinity stress on seed germination and seedling growth of tomato.

Chaney, N. W., Minasny, B., Herman, J. D., Nauman, T. W., Brungard, C. W., Morgan, C. L., . . . Yimam, Y. (2019). POLARIS soil properties: 30- m probabilistic maps of soil properties over the contiguous United States. *Water Resources Research, 55*(4), 2916-2938.

Choi, J.-H., Edwards, P., Ko, K., & Kim, Y.-S. (2016). Definition and classification of fault damage zones: A review and a new methodological approach. *Earth-Science Reviews, 152*, 70-87.

Chukwu, M. A. (2018). Thesis submitted for the Degree of Doctor of Philosophy.

Coyle, C., Creamer, R. E., Schulte, R. P., O'Sullivan, L., & Jordan, P. (2019s). A functional land management conceptual framework under soil drainage and land use scenarios. *Environmental Science & Policy, 56,* 39-48.

Dada, C., Kayode, J., & Arowosegbe, S. (2019). The effects of different types of soil on germination and early seedling development of Annona muricata Linn. *East African Scholars Journal of Agriculture and Life Sciences, 2*(5), 236-241.

De Oliveira, I. A., de Freitas, L., de Aquino, R. E., Casagrande, J. C., Campos, M. C. C., & Silva, L. S. (2018). Chemical and physical pedoindicators of soils with different textures: spatial variability. *Environmental Earth Sciences, 77,* 1-12.

Dubey, M., & Verma, N. (2022). Definition of soil. *Advances in Agricultural and Horticultural Sciences, 696.*

Finch-Savage, W. E., & Bassel, G. W. (2016). Seed vigour and crop establishment: extending performance beyond adaptation. *Journal of experimental botany, 67*(3), 567-591.

Follmer, C. M., Hummes, A. P., Lângaro, N. C., Petry, C., Moterle, D. F., & Bortoluzzi, E. C. (2021). Nutrient availability and pH level affect germination traits and seedling development of Conyza canadensis. *Scientific reports, 11*(1), 15607.

Grossnickle, S. C., & MacDonald, J. E. (2018). Why seedlings grow: influence of plant attributes. *New forests*, *49*, 1-34.

Gupta, A., & Kumar, R. (2020). Management of seed-borne diseases: an integrated approach. *Seed-borne diseases of agricultural crops: detection, diagnosis & management*, 717-745.

Huang, J., & Hartemink, A. E. (2020). Soil and environmental issues in sandy soils. *Earth-Science Reviews, 208*, 103295.

Javaid, M. M., Florentine, S., Ali, H. H., & Weller, S. (2018). Effect of environmental factors on the germination and emergence of Salvia verbenaca L. cultivars (verbenaca and vernalis): An invasive species in semi-arid and arid rangeland regions. *PLoS One, 13*(3), e0194319.

Jerem, P., & Mathews, F. (2021). Trends and knowledge gaps in field research investigating effects of anthropogenic noise. *Conservation Biology, 35*(1), 115-129.

sKalev, S. D., & Toor, G. S. (2018). The composition of soils and sediments. In *Green Chemistry* (pp. 339-357): Elsevier.

Kaur, G., Singh, G., Motavalli, P. P., Nelson, K. A., Orlowski, J. M., & Golden, B. R. (2020). Impacts and management strategies for crop production in waterlogged or flooded soils: A review. *Agronomy Journal, 112*(3), 1475-1501.

Kaur, N., Erickson, T. E., Ball, A. S., & Ryan, M. H. (2017). A review of germination and early growth as a proxy for plant fitness under petrogenic contamination—knowledge gaps and recommendations. *Science of The Total Environment, 603*, 728-744.

Khalifa, S. A., Elshafiey, E. H., Shetaia, A. A., El-Wahed, A. A. A., Algethami, A. F., Musharraf, S. G., . . . Abdel-Daim, M. M. (2021). Overview of bee pollination and its economic value for crop production. *Insects, 12*(8), 688.

Khan, U. M., Sevindik, M., Zarrabi, A., Nami, M., Ozdemir, B., Kaplan, D. N., . . . Alshehri, M. M. (2021). Lycopene: Food sources, biological activities, and human health benefits. *Oxidative medicine and cellular longevity, 2021*.

Koza, W. (2022). *Effects of climate variability on small-scale production of tomatoes (solarium lycopersicum) in Mopani District of Limpopo Province, South Africa.*

Lamichhane, J. R., Debaeke, P., Steinberg, C., You, M. P., Barbetti, M. J., & Aubertot, J.-N. (2018). Abiotic and biotic factors affecting crop seed germination and seedling emergence: a conceptual framework. *Plant and soil, 432*, 1-28.

Liao, W., & Thomas, S. C. (2019). Biochar particle size and post-pyrolysis mechanical processing affect soil pH, water retention capacity, and plant performance. *Soil Systems, 3*(1), 14.

Liliane, T. N., & Charles, M. S. (2020). Factors affecting yield of crops. *Agronomy-climate change & food security*, 9.

Longo, C., Holness, S., De Angelis, V., Lepri, A., Occhigrossi, S., Ruta, V., & Vittorioso, P. (2020). From the outside to the inside: New insights on the main factors that guide seed dormancy and germination. *Genes, 12*(1), 52.

Makhubelo, D. N. (2023). *The challenges associated with footwall clay in offshore diamond mining.* Stellenbosch: Stellenbosch University,

Manfredi, P., Cassinari, C., Gatti, M., & Trevisan, M. (2019). Growth and yield response of tomato (Solanum lycopersicum L.) to soil reconstitution technology. *Agrochimica: International Journal of Plant Chemistry, Soil Science & Plant Nutrition of the University of Pisa, 63*(1).

Martínez-Ballesta, M. d. C., Egea-Gilabert, C., Conesa, E., Ochoa, J., Vicente, M. J., Franco, J. A., . . . Fernández, J. A. (2020). The importance of ion homeostasis and nutrient status in seed development and germination. *Agronomy, 10*(4), 504.

Msimbira, L. A., Naamala, J., Antar, M., Subramanian, S., & Smith, D. L. (2022). Effect of microbial cell-free supernatants extracted from a range of pH levels on corn (Zea mays L.) and tomato (Solanum lycopersicum L.) seed germination and seedling growth. *Frontiers in Sustainable Food Systems, 6*, 789335.

Muragi, A. R., & Sajjan, M. (2019). Seedling tansplanter. *International Journal for Research in Applied Science & Engineering Technology (IJRASET). 7*(II).

Nazar, S., Jeyaseelan, M., & Jayakumararaj, R. (2022). Local Health Traditions, Cultural Reflections and Ethno-taxonomical Information on Wild Edible Fruit Yielding Medicinal Plants in Melur Region of Madurai District, TamilNadu, India. *Journal of Drug Delivery and Therapeutics, 12*(3), 138-157.

Osman, K. T. (2018). *Management of soil problems*: Springer.

Pan, J., Sharif, R., Xu, X., & Chen, X. (2021). Mechanisms of waterlogging tolerance in plants: Research progress and prospects. *Frontiers in Plant Science, 11*, 627331.

Perez-Harguindeguy, N., Diaz, S., Garnier, E., Lavorel, S., Poorter, H., Jaureguiberry, P., . . . Gurvich, D. E. (2016). Corrigendum to: New handbook for standardised measurement of plant functional traits worldwide. *Australian Journal of botany, 64*(8), 715-716.

Pignata, G., Casale, M., & Nicola, S. (2017). Water and nutrient supply in horticultural crops grown in soilless culture: resource efficiency in dynamic and intensive systems. *Advances in research on fertilization management of vegetable crops*, 183-219.

Richer-de-Forges, A. C., Arrouays, D., Chen, S., Dobarco, M. R., Libohova, Z., Roudier, P., . . . Bourennane, H. (2022). Hand-feel soil texture and particle-size distribution in central France. Relationships and implications. *Catena, 213*, 106155.

Sah, S., Johar, V., & Karthi, J. (2022). Status and marketing of fruits and vegetables in India: A review. *Asian Journal of Agricultural Extension, Economics & Sociology, 40*(7), 1-11.

Seifu, W., & Elias, E. (2018). Soil quality attributes and their role in sustainable agriculture: a review. *International Journal of Plant & Soil Science, 26*(3), 1-26.

Senesi, N., & Loffredo, E. (2018). The chemistry of soil organic matter. In *Soil physical chemistry* (pp. 239-370): CRC press.

Stark, J. C., Thornton, M., & Nolte, P. (2020). *Potato production systems*: Springer Nature.

Thomas, P. (2014). *Trees: their natural history*: Cambridge University Press.

Tolosa, L. N., & Zhang, Z. (2020). The role of major transcription factors in Solanaceous food crops under different stress conditions: Current and future perspectives. *Plants, 9*(1), 56.

Tong, J., Yu, J., Wu, C., Yu, G., Du, X., & Shi, H. (2021). Health information acquisition and position calculation of plug seedling in greenhouse seedling bed. *Computers and Electronics in Agriculture, 185*, 106146.

Tumsing Magar, G. M. (2015). *A study of tomato farming in Rajghat VDC of Sarlahi district Nepal.* Department of Rural Development,

Unkovich, M., McBeath, T., Llewellyn, R., Hall, J., Gupta, V. V., & Macdonald, L. M. (2020). Challenges and opportunities for grain farming on sandy soils of semi-arid south and south-eastern Australia. *Soil research, 58*(4), 323-334.

Xi, N., Bloor, J. M., & Chu, C. (2020). Soil microbes alter seedling performance and biotic interactions under plant competition and contrasting light conditions. *Annals of Botany, 126*(6), 1089-1098.

Yu, C., Mawodza, T., Atkinson, B. S., Atkinson, J. A., Sturrock, C. J., Whalley, R., . . . Zhou, H. (2024). The effects of soil compaction on wheat seedling root growth are specific to soil texture and soil moisture status. *Rhizosphere, 29*, 100838.

5.6 Appendices