BINDURA UNIVERSITY OF SCIENCE EDUCATION

DEPARTMENT OF CROP SCIENCE

EFFECTS OF SOIL MOISTURE AND SOIL TYPE ON SEED GERMINATION AND EARLY GROWTH OF MAIZE (ZEA MAYS) FOR WINTER CROPPING.

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B1954003

A DISSERTATION SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS OF THE BACHELOR OF AGRICULTURAL SCIENCE HONOURS DEGREE

(CROP SCIENCE)

SUPERVISORS; MR MUTSENGI AND MR CHIKASHA

BINDURA UNIVERSITY OF SCIENCE EDUCATION

FUCULTY OF AGRICULTURE AND ENVIRONMENTAL SCIENCE

RESEACH PROJECT SUBMISSION APPROVAL FORM

This reseach project is the outcome of my original reseach work, and im submitting it to fullfill

The requirements of the Bachelor of Agricultural Science Honours Degreein Crop Science. As faras im aware, the results presented in this project have not been submitted to any other instistutions before, nor are they being currently submitted elsewhere.

(**STUDENT)**

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As the supervisor of the aforementioned student's reseach project, I can attest that the project is ready for submission.

(SUPERVISORS)

1. NAME: Mr Chikasha

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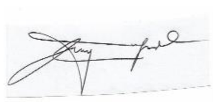
Chairman: Mr. mutsengi

 **pp**

DECLARATION

I Ben Paso do hereby declare that this dissertation was the result of my own original efforts and investigation and such work has not been presented elsewhere for any degree or any university program. All other supplementary sources of information have been acknowledged by means of references.

Ben Paso

Registration Number B1954003

Signature…………………………………

Date…………………………………………

CERTIFICATION OF THE DISSERTATION

Bindura University of Science Education

Department of Crop Science

The undersigned certify that they have read and recommend to the Bindura University to accept a dissertation entitled : **EFFECTS OF SOIL MOISTURE AND SOIL TYPE ON SEED GERMINATION AND EARLY GROWTH OF MAIZE (ZEA MAYS).**

Submitted by

Ben Paso

B1954003

In partial fulfillment of the requirements for the Bachelor of Science Honors Degree in Agriculture.

DATE………………………………………………………………

DEDICATION

To my parents with love, Mr and Mrs Paso l love you yesterday and forever.

ACKNOWLEDGEMENTS

First off, I want to express my appreciation to Mr Mutsengi and Mr Chikasha, who oversaw my project, for showing an interest in my academic growth and providing guidance, mentorship, and support throughout the study. I would like to express my gratitude to the Astra campus co-works, and the whole of Bindura University for allowing me to use their resources and for their support throughout the study. My sincere gratitude goes out to Marshal Dakwa and Panashe Kusikwenyu team for their assistance with the experimental setup and data collection Thank you to my family for your financial and emotional support. Your prayers, Mom and Dad, took me this far. God bless you all.

Abstract

Soil type and soil moisture are essential for seed germination and for early development of maize seedling. The study was conducted to assess germination percentage, biomass weight and stem height of *Zea mays* under different soil moisture levels and soil type in maize winter production. The experiment was laid down in a Randomised Complete Block Design arranged in a factorial manner. There were two factors which were soil type and soil moisture level. There were four moisture levels which were 30%, 40%, 70% and 100%. Soil type had sand soils and clay soils. The results indicated that there was no significant effect on soil type and soil moisture levels in maize germination ($p=0.297$). Moisture content also showed no significant interaction in germination ($p=0.324$). there was a significant interation in soil type and moisture content in biomass weight ($p=0.038$) and soil type also showed significant effects ($p=0.04$). Soil type in stem height showed no significant effects ($p=0.707$). The trial outcome strongly recommends farmers to consider for greater germination percentage and maximal early development in sand soils, to use 30% and 70% moisture content, respectively.

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CHAPTER 1

1.1 INTRODUCTION

Seed germination and early growth in maize (*Zea mays)* is an essential aspect that directly influences crop yield and productivity. According to Sahoo *et al.*, (2019).soil moisture is a key factor that affects the germination and early growth of maize seeds, with inadequate or excessive moisture affecting the process. Soil type on the other hand also have limitation to germination and early growth of maize.

According to Singh *et al.*, (2018), the optimal range of soil moisture for maize seed germination is 25-40% under clay soils. This range provides adequate water content and soil holding capacity for the seeds to imbibe, germinate, and develop into healthy seedlings. In contrast, lower soil moisture content mostly in sand soils, limits seed germination and can cause seedling death, while excess moisture can lead to soil compaction, seed decay, and other adverse effects. Soil water holding capacity is the ability of soils to hold water which is available to plants. According to Mutava *et al*., (2019) adequate soil moisture and soil type is critical to crop growth and development especially at early stages of maize.

Faisal *et al.*, (2020) noted that adequate soil moisture is necessary for optimal seedling growth in maize. Soil type and soil moisture influences many variables such plant physiology, photosynthesis and nutrient uptake. The authors found that under stress conditions such as water deficit, the seeds recorded low germination rates and exhibited poor growth characteristics. Similarly, Begum *et al*., (2018) observed that excessive soil moisture in clay soil with low drainage ability interfered with seed germination and caused seedling death.

Several studies have also explored the responses of maize seed germination to different soil moisture regimes. For instance, Razzaq *et al*., (2016) noted that soil moisture levels above 25% of field capacity increased the time to germination and reduced the germination percentage.

This study seeks to evaluate the germination behaviour and early growth of maize seeds under different soil moisture regimes and soil types. The study will evaluate issues such as the effects of soil moisture and soil type on germination percentage, stem height and biomass weight. The results of this study will have significant implications for winter crop production and provide evidence-based insight into maize seed germination under different soil type and soil moisture conditions.

1.2 Problem statement

We do not know the effects of different soil type and soil moisture levels on germination and performance of maize on early growth. There is also a lack of comprehensive understanding of how moisture and soil interact and influence the germination and early growth of maize.

1.3 Justification

To address these problems, different moisture levels and soil types can be observed during the experiment to come up with most recommended moisture content and soil type required for germination and to maintain vigour of early growth of maize. It is important to consider moisture levels and soil type as it directly affects germination percentage, biomass weight and stem height.

1.4 Aim Objective

To determine the effects of soil type and moisture levels on germination and early growth of maize production.

1.5.1 Specific objective

1. To determine the effects of soil moisture level and soil type on germination of maize
2. To evaluate the effects of different soil moisture levels and soil type on stem height.
3. To evaluate the effects different moisture levels and soil type on biomass weight of maize.

1.6 Hypothesis

- Different soil type and moisture levels have an effect on germination percentage.
- Different soil type and soil moisture levels have an effect on biomass weight of maize
- Different soil type and moisture levels have an effect on stem height of maize

CHAPTER 2

2.1 LITERATURE REVIEW

Maize, also known as corn, is a widely used grain crop that has been cultivated for thousands of years. It is an essential staple food in Zimbabwe and is also used in animal feed, biofuels, and industrial applications. Maize is also used in processed food products such as cereals, snacks, and baking mixes. According to FAO (2018), maize is the world's third most important cereal crop, after wheat and rice.

Maize is an essential source of animal feed, particularly for poultry and livestock. It is rich in carbohydrates, protein, and essential amino acids, making it a nutritious feed for animals, (Owens *et al.,* 2019). Research has shown that including maize in animal feed can improve growth rates and increase the efficiency of feed conversion (Owens *et al.,* 2019).

Maize is used in a variety of industrial applications, including the production of starch, sweeteners, and other chemicals Maize starch is used in food, paper, and textile industries, while maize oil is used in cooking and as a feedstock for biodiesel production. Research has shown that maize-based industrial products have a range of applications and can help to reduce dependence on fossil fuels.

2.2 Soil factors affecting germination and early growth of maize

Soil is an essential component of the ecosystem, playing a vital role in sustaining life, especially in agriculture (Marschner, 2012). It provides a supportive medium for plant growth, supplies essential nutrients, water, and oxygen to plant roots while serving as a habitat for soil organisms. The ability of plants to germinate and establish successfully is influenced by various soil factors, including soil type.

According to Ghosh *et al.,* (2018), germination is directly impacted by soil composition, including mineral concentration, organic matter, and soil pH. Different soil types have unique compositions, and this can have a big impact on crop germination. Large particles and a poor ability to retain moisture and nutrients are characteristics of sandy soils. Sandstone soils have a porous nature that encourages adequate aeration, but because they tend to drain quickly, seeds may experience water stress during germination. Clay soils, in contrast, have tiny particles that offer high water and nutrient retention. However, because of how compact they are, water infiltration and root penetration may be hampered, perhaps resulting in seedling root rot and subpar germination rates.

Furthermore soil structure influences the porosity and compaction levels, ultimately influencing the availability of water, air, and root penetration for germinating seeds. Good soil structure allows sufficient water infiltration and drainage while providing roots with ample oxygen. Sandy soils, due to their large particles, possess excellent drainage properties but often lack water holding capacity, causing challenges during germination. On the other hand, clay soils, with their fine particles, tend to become waterlogged, leading to poor aeration and hindered seedling emergence. Study conducted by Kaur *et al*., (2017) showed that the cohesive nature of clay soils also restricts root elongation.

For crops to germinate and grow, soil must have the ability to retain water (Kopitke *et al.,* 2019). It is influenced by the organic matter concentration, soil compaction, and soil texture. Because the particles in sandy soils are bigger, they tend to drain more quickly, which results in poor water retention. According to Kaur *et al.,* (2017), this can result in inadequate moisture for seed germination, sluggish or unsuccessful germination rates. Clay soils, on the other hand, can contain a lot of water due to their compacted structure, which can cause waterlogging and reduce the oxygen available for root respiration.

Essential plant nutrients are stored in the soil, and their availability affects the growth of young plants. (2016) Tariq *et al*. Due to the small surface area that their bigger particles give, sandy soils typically have inferior nutrient-holding capabilities. As a result, sandy soils frequently have nutritional deficits that prevent seedling germination and early vigor. (2017) Kwasi *et al*. Contrarily, the great capacity of clay soils to store nutrients often results in higher levels of nutritional fertility.

2.3 Effects of moisture on germination and early growth

Water is essential for germination because it starts the seed's internal metabolic activities. First, water softens the seed coat, causing the seed to enlarge, before moisture is engaged in beginning metabolic processes. The activation of enzymes and the absorption of nutrients required for growth depend on adequate moisture levels.

However, although too little moisture might harm maize seed germination, too much moisture can result in oxygen deprivation and possible bacterial or fungal diseases. According to a 2018 article by Kawser *et al.*, the seed coat remains hard when moisture availability is low, preventing water from entering the seed and limiting the start of enzymatic activity. Inadequate hydration also limits the hydrolytic enzymes' capacity to break down reserves, which reduces the amount of energy available for embryo growth. Additionally, insufficient moisture can cause cell elongation activities to slow down or stop, delaying or impairing the development of the radicle and cotyledons, Sirisha (2019). Low moisture availability can cause cell death and desiccation in the embryo, which can put the seed into dormancy or cause it to die.

2.4 Germination of maize

Uddin, (2018) posted that seed germination is a crucial process in the production of maize (Zea mays). Successful seed germination ensures a good start to crop growth and development, leading to high yield and productivity. Several factors such as soil moisture, temperature, nutrients, and seed quality influence maize seed germination

A plant's growth from a seed to a seedling begins with the germination process, which is an important phase in the life cycle of a plant. In order for the embryo inside the seed to emerge and grow into a new plant, Rao *et al.,* (2015) claim that germination entails a series of intricate physiological and biochemical processes. Imbibition, the process by which the seed takes up water, is the first step in the germination process. When stored reserves are hydrolyzed to release energy and nutrients for growth, water is required to activate enzymes and metabolic processes within the seed. Water absorption weakens the seed coat, which leads to the rehydration of latent embryonic cells.

Several enzymatic actions are initiated once enough water has been absorbed, according to Gebrehiwot (2018). These enzymes convert carbohydrates, lipids, and proteins that have been stored into simpler forms so that the growing seedling can consume them. Amylase enzymes, for instance, convert starches into sugars, supplying the energy needed for cellular respiration and development. The embryo inside the seed starts to grow when metabolic processes are activated. The radicle, or embryonic root, emerges as the first audible indicator of germination. In addition to anchoring the seedling and taking up water and nutrients from the soil, the radicle spreads downward into the ground.

The cotyledons, or seed leaves, expand along with the radicle as it grows further. Before the seedling can photosynthesize and make its own food through the leaves, the cotyledons act as temporary structures that supply it with energy and nutrients (Kamal, 2018).

The cotyledons are pushed above the soil surface during this stage by the elongation of the cotyledons' neighboring regions, the radicle and hypocotyl, as well as the elongation of the epicotyl, which develops into the stem and the first genuine leaves, which eventually take the place of the cotyledons. This procedure promotes emergence, photosynthesis, and germination, enabling the seedling to make its own food.

2.5 Factors Affecting Germination

The germination of seeds is highly dependent on temperature. For the best germination, each plant species has certain temperature needs. According to Koocheki (2017), seeds typically require a temperature range that is optimal for enzyme activity and metabolic processes. Germination can be slowed down by low temperatures, and it can be prevented or even damaged by high temperatures.

Certain plant species' germination is influenced by light as an environmental signal. While some seeds exhibit negative photoblastic reactions and need darkness for germination, others do the opposite and exhibit positive photoblastic responses. Light-dependent signaling pathways that control germination can be activated by the presence or absence of light.

During the germination process, seeds require oxygen for cellular respiration Kamal, (2018). Adequate oxygen availability is crucial for energy production and proper metabolic functioning. Waterlogged conditions can lead to reduced oxygen levels, inhibiting germination and potentially causing seed rot.

2.6 Physiological Changes during Germination

According to Rani (2015), germination entails the seed's stored reserves being released. In order for the developing seedling to use complex carbohydrates, lipids, and proteins as a source of energy and nutrition, enzymes must be activated.

Gibberellins and abscisic acid are two hormones that are crucial in controlling germination. While abscisic acid regulates seed dormancy and prevents germination in unfavorable conditions, gibberellins boost the creation of hydrolytic enzymes needed for the breakdown of stored reserves and encourage cell elongation.

As germination progresses, cell expansion and growth occur in the root and shoot. These processes are facilitated by water absorption and the activation of various growth-promoting hormones, allowing the seedling to emerge from the soil and develop into a young plant.

CHAPTER 3

3.1 Site description

The study was carried out at Bindura University of science education at Astra Campus which is geographical located at coordinates -17.316143 S and 31.323130 E. The area is located in the natural region 2b; this area receives 750-1000mm of rainfall per annum. The average temperature ranges from 16-28 degrees Celsius in winter season.

3.2 Experimental design and Layout Trials

The trial was laid down in an Randomised Complete Block Design arranged in a factorial manner. There were two factors; soil type and moisture content. There were four moisture content levels which were 30%, 40%, 70% and 100%. There were two soil type sand and clay. The trials were replicated three times.

3.2.1 Experimental management

To calculate different moisture content, water was added in 2 pots of clay and 2 pots sand to saturation point was labelled 100%. Water was added using a beaker to measure the water required to reach saturation point, 790ml and 550ml were recorded in clay and sand respectively.

Calculation for different moisture in clay soils

- 30/100 * 790ml = 237 ml
- 40/100 * 790ml= 316 ml
- 70/100 * 790ml= 553ml

Calculation for different moisture in sand soil

- 30/100 * 550=165 ml

- 40/100 * 550= 220 ml
- 70/100 * 550= 385 ml

3.4 Data collection

3.4.1 Germination percentage rate

240 seeds of maize were in 48 pots; in each pot 5 seeds were planted. To calculate different germination, rate the number of seeds that emerged in each pot were counted. Number of seeds that emerged multiplied by 100 divided by number of seeds planted.

3.4.1 Stem height

Stem height was measured using a ruler and a string in centimeters. The height was measure from the soil surface to the shoot tips.

3.4.3Biomass weight

To measure biomass weight, plants were carefully uprooted after soaking the pots with water and thoroughly washed to remove all the dirt. The fresh seedlings were weighed, and dried then weighed to get the actual biomass of the plant.

3.5 Data analysis

All data was subjected to analysis of variance using GENSTAT STATISTICAL PACKAGE 17^{th} Edition and results were tested at 5 % significant level in which two way analysis of variance for RCBD was done. Computed p values from Genstat were used to determine if there is differences.

CHAPTER 4

RESULTS

4.1 The Effects of Soil Type and Moisture Content on Maize Germination %

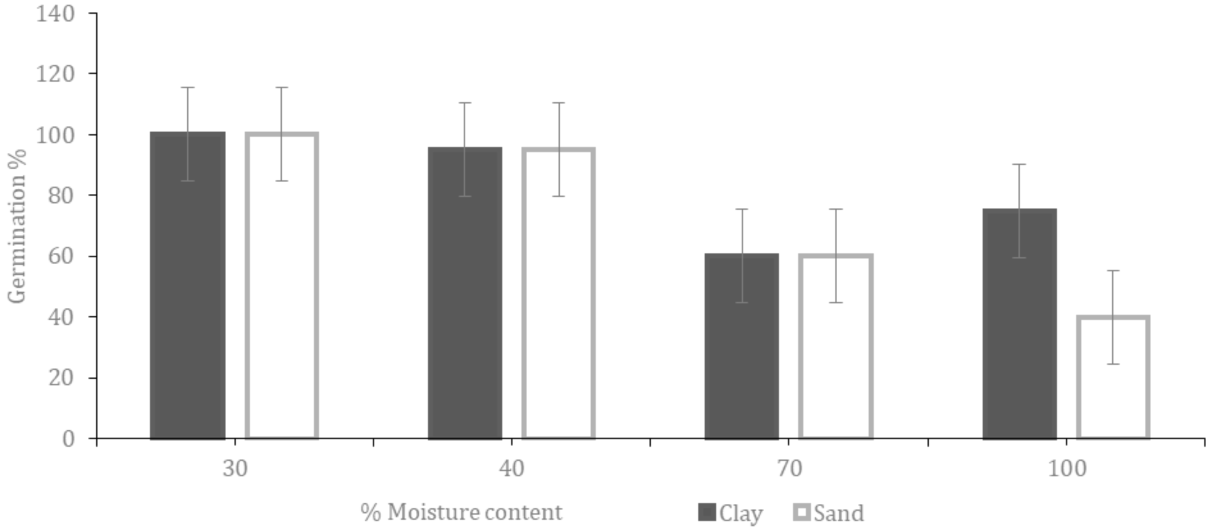

Figure 4.1.1 shows the effect of soil type and moisture content on maize germination.

There is no significant interaction between soil type and moisture levels on maize germination where ($p=0.297$). Soil moisture had no significant effect on maize germination ($p=0.324$). The results also showed that soil type had no significant interaction on germination of maize ($p=0.265$).

4.1 The Effects of Soil Type and Moisture Content on Maize Stem Height

Fig 4.1.2

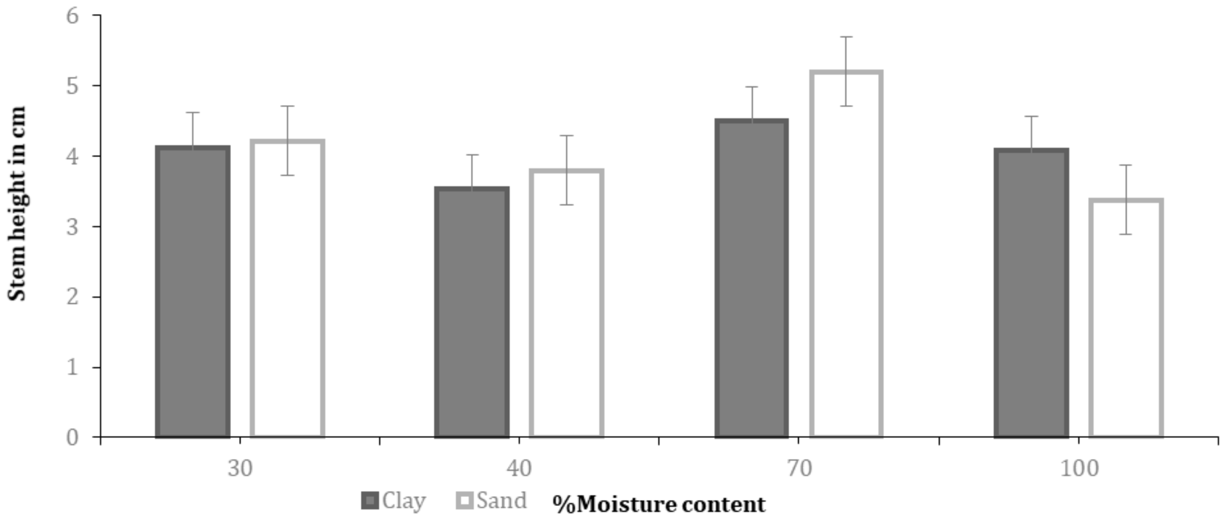

Figure 4.2.2 shows the effect of soil type and moisture content on maize stem height.

There is no significant interaction between soil moisture content and soil type on maize stem height where p=0.264. The results also showed that soil type had no significant effect on maize stem height. Soil moisture showed no significant effect on stem height.

4.1 The Effects of Soil Type and Moisture Content on Maize Biomass Weight

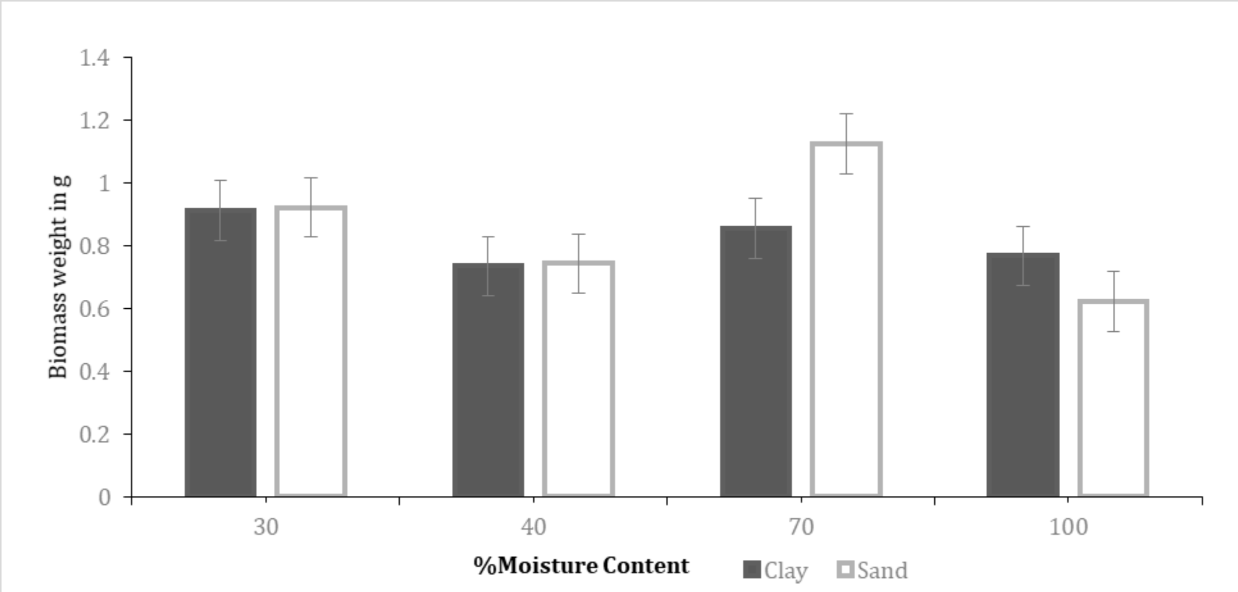

Figure 4.3.3 shows the effects of soil type and moisture content on maize biomass weight.

The results showed significant effect between soil type and soil moisture levels on biomass weight of maize where ($p=0.038$) (fig 4.3.3). Soil type also showed a significant effect on biomass weight of maize where ($p= 0.041$). Soil moisture content had a signficant effect on biomass wieght.

CHAPTER 5

Discussion of results

5.1 Germination percentage results

There is no significant interaction between soil type and moisture levels on maize germination. These findings are in contrast to previous studies that have reported soil type and moisture content as crucial factors in maize seed germination. Variations in experimental settings, including temperature, light exposure, and seed quality, may account for discrepancies in these results. Because seeds can tolerate a larger range of soil types and moisture levels, they can sprout in a variety of environments without experiencing a substantial interaction impact.

A deeper understanding of maize germination may result from taking into account the importance of seed quality, including its genetics and physiological status. (2015) Rao et al.

There were no appreciable differences in germination rates between soil types and moisture content levels, however sand and clay soils with a 30% moisture content showed the highest rates. The complexity of seed germination is highlighted by these findings.

5.3 Stem Height

The results from these study conducted no significance effect on soil type and soil moisture. Although 70% moisture content in sand soil had the highest stem height. This is because sand soils with high moisture content encourage fast growth leading to development of weak elongated stems. Plants that are grown in wetter soils tend to have a taller stem than those grown in soils with lower moisture content.

Soil moisture showed no significant effect on stem height. Plants have the abaility to compensate for suboptimal conditions by altering their growth patterns. For example plants may grow taller in response to limited moisture to seek out more favourable conditions. These compensatory growth may mask any significant interation between soil type and moisture content on stem height.

5.2 Biomass Weight Results

There is a significant effect between soil type and soil moisture levels on biomass weight of maize(p=0.038). However, the lowest biomass weight in sand soil was discovered at 100% moisture content. Soil type also showed a significant effect on biomass weight of maize (p= 0.041). Nutrient level and composition vary depending on the kind of soil. A more favorable nutritional profile for plant growth may be offered by specific soil types, which could improve biomass weight. Similary, moisture content influences availability, nutrient uptake, and transport, resulting in increased biomass.

Soil moisture content had a signficant effect on biomass wieght. Water availability to plants is directly impacted by the moisture level of the water. The ability of plants to maintain appropriate hydration, which is essential for the process of photosynthesis, depends on the amount of moisture in the soil. A higher moisture level encourages favorable conditions for plant growth, increasing the weight of the biomass. Because high soil moisture concentrations result in, which contributes to the plant's biomass weight, sand soil with a 70% moisture content yielded the maximum biomass weight.

CHAPTER 6

CONCLUSION AND RECOMMENDATION

6.1 CONCLUSION

According to the study, the germination percentage of maize is not significantly affected by soil type or moisture levels. According to the stem height results, neither the soil type nor the soil moisture content had a discernible impact. Sand soil with a 70% moisture content appeared to produce the largest stem height and the highest biomass weight.

6.2 RECOMMENDATION

Maintaining the ideal soil moisture content and soil type is crucial for the effective germination and early growth of *Zea mays* seedlings. For greater germination percentage and maximal early development in sand soils, I advise farmers to use 30% and 70%, respectively. To comprehend the precise circumstances and elements that affect germination and early growth in soil types and moisture content, it is crucial to perform additional research and experiments.

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APPENDICES:

Analysis of variance

Variate: Germination_%

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Block stratum					
Moisture_Content	3	0.56	612.5	1.30	0.324
Block.*Units* stratum					
Soil_type	1	612.5	612.5	1.30	0.265
Soil_type.Moisture_Content	3	1837.5	612.5	1.30	0.297
Residual	24	11300.0	470.8		
Total	31	25887.5			

Information summary

All terms orthogonal, none aliased.

Message: the following units have large residuals.

Block 3 *units* 2	-40.0	s.e.	18.8
Block 4 *units* 4	-55.0	s.e.	18.8
Block 4 *units* 6	40.0	s.e.	18.8

Tables of means

Variate: Germination_%

Grand mean 78.1

Soil_type	Clay	Sand
	82.5	73.8

Moisture_Content	30	40	70	100
	100.0	95.0	60.0	57.5

Soil_type	Moisture_Content	30	40	70	100
Clay		100.0	95.0	60.0	75.0
Sand		100.0	95.0	60.0	40.0

Standard errors of means

Table	Soil_type	Moisture_Content	Soil_type Moisture_Content
rep.	16	8	4
d.f.	24	*	*
e.s.e.	5.42	*	*

Except when comparing means with the same level(s) of
Moisture_Content

10.85

Standard errors of differences of means

Table	Soil_tye	Moisture_Content	Soil_tye Moisture_Content
rep.	16	8	4
d.f.	24	*	*
s.e.d.	7.67	*	*

Except when comparing means with the same level(s) of
Moisture_Content

15.34

Least significant differences of means (5% level)

Table	Soil_tye	Moisture_Content	Soil_tye Moisture_Content
rep.	16	8	4
d.f.	24	*	*
l.s.d.	15.83	*	*

Except when comparing means with the same level(s) of
Moisture_Content

31.67

Stratum standard errors and coefficients of variation

Variate: Germination_%

Stratum	d.f.	s.e.	cv%
Block	0	*	*
Block.*Units*	24	21.70	27.8

Analysis of variance

Variate: Stem_height_in_cm

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Block stratum	1	7.2009	2.4003		
Moisture_Content	3	2.0609	0.6870	1.41	0.264
Block.*Units* stratum					
Soil_tye	1	0.0703	0.0703	0.14	0.707
Soil_tye.Moisture_Content	3	2.0609	0.6870	1.41	0.264
Residual	24	11.6975	0.4874		
Total	31	21.0297			

Information summary

All terms orthogonal, none aliased.

Message: the following units have large residuals.

Block 3 *units* 1	1.30	s.e.	0.60

Tables of means

Variate: Stem_height_in_cm

Grand mean 4.10

Soil_tye	Clay	Sand
	4.06	4.15

Moisture_Content	30	40	70	100
	4.17	3.66	4.85	3.73

Soil_tye	Moisture_Content	30	40	70	100
Clay		4.12	3.53	4.50	4.08
Sand		4.22	3.80	5.20	3.38

Standard errors of means

Table	Soil_tye	Moisture_Content	Soil_tye Moisture_Content
rep.	16	8	4
d.f.	24	*	*
e.s.e.	0.175	*	*

Except when comparing means with the same level(s) of Moisture_Content

			0.349

Standard errors of differences of means

Table	Soil_tye	Moisture_Content	Soil_tye Moisture_Content
rep.	16	8	4
d.f.	24	*	*
s.e.d.	0.247	*	*

Except when comparing means with the same level(s) of Moisture_Content

			0.494

Least significant differences of means (5% level)

Table	Soil_tyeMoisture_Content		Soil_tye Moisture_Content
rep.	16	8	4
d.f.	24	*	*
l.s.d.	0.509	*	*

Except when comparing means with the same level(s) of
Moisture_Content

			1.019

Stratum standard errors and coefficients of variation

Variate: Stem_height_in_cm

Stratum	d.f.	s.e.	cv%
Block	0	*	*
Block.*Units*	24	0.698	17.0

Analysis of variance

Variate: Biomass_weight_in_grams

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Block stratum					
Moisture_Content					
	3	0.17801	0.05934	3.77	0.034
Block.*Units* stratum					
Soil_tye	1	0.01015	0.01015	3.56	0.041
Soil_tye.Moisture_Content					
	3	0.17801	0.05934	3.27	0.038
Residual	24	0.43488	0.01812		
Total	31	1.10060			

Information summary

All terms orthogonal, none aliased.

Message: the following units have large residuals.

Block 3 *units* 1	0.245	s.e.	0.117
Block 3 *units* 7	0.275	s.e.	0.117

Tables of means

Variate: Biomass_weight_in_grams

Grand mean 0.835

Soil_tye	Clay	Sand
	0.817	0.853

Moisture_Content	30	40	70	100
	0.917	0.739	0.990	0.695

Soil_tye	Moisture_Content	30	40	70	100
Clay		0.912	0.735	0.855	0.768
Sand		0.922	0.743	1.125	0.623

Standard errors of means

Table Soil_tyeMoisture_Content

		Soil_tye	
		Moisture_Content	
rep.	16	8	4
d.f.	24	*	*
e.s.e.	0.0337	*	*

Except when comparing means with the same level(s) of
Moisture_Content

			0.0673

Standard errors of differences of means

Table	Soil_tye	Moisture_Content	Soil_tye
			Moisture_Content
rep.	16	8	4
d.f.	24	*	*
s.e.d.	0.0476	*	*

Except when comparing means with the same level(s) of
Moisture_Content

			0.0952

Least significant differences of means (5% level)

Table	Soil_tye	Moisture_Content	Soil_tye
			Moisture_Content
rep.	16	8	4
d.f.	24	*	*
l.s.d.	0.0982	*	*

Except when comparing means with the same level(s) of
Moisture_Content

			0.1964

Stratum standard errors and coefficients of variation

Variate: Biomass_weight_in_grams

Stratum	d.f.	s.e.	cv%
Block	0	*	*
Block.*Units*	24	0.1346	16.1