BINDURA UNIVERSITY OF SCIENCE EDUCATION

FACULTY OF AGRICULTURE AND ENVIRONMENTAL SCIENCE DEPARTMENT OF CROP SCIENCE

Investigation on the effects of variety and Agrisilica on water retention, growth rate and yield of maize

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DECLARATION

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The undersigned certify that they have read and recommend to the Department of Crop Science, this thesis entitled:

Investigation on the effects of variety and Agrisilica on water retention, growthrate and yield of maize.

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ABSTRACT

Maize productivity in Zimbabwe remains low especially among communal farmers because of drought and poor soil fertility, necessitating innovative solutions like agrisilica application. This study aimed to assess the effect of variety and agrisilica on water retention, growth rate and yield of maize in semi-arid conditions. A 2×4 experiment laid in a randomized complete design was conducted at Superfert Bindura with two varieties (SC 555 AND SC 657) and 4 basal fertilizer levels (agrisilica, compound D, agrisilica + compound, no fertilizer). Results showed that agrisilica especially when combined with compound D, significantly improved growth rate, soil moisture content and yield, with SC 555 outperforming SC 657. The study concludes that integrating agrisilica into maize farming enhances drought resilience and productivity. It is recommended for adoption by farmers in dry regions to ensure food security and sustainable agriculture.

ACKNOWLEDGEMENTS

My appreciation goes to my supervisors Prof. Mandumbu and Mr. Chitamba for their guidance and advice during this research project with the absence of their guidance and encouragement this project would not been completed. I would also like to appreciate my fellow mates Rumbidzai and Nyasha for their moral and academy support during this academic journey. I would also like to acknowledge Superfert Bindura Company for providing land and inputs for the research.

DEDICATION

I dedicate this project to my partner Robert for offering financial and emotional support through the degree program. I also extend the dedication to Mr. Gutsa at Superfert Bindura for his assistance during this research period.

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CHAPTER 1: INTRODUCTION

1.1 Background

Maize (*Zea mays*) is a tall annual monoecious grass with separate male and female flowers on the same plant and it belongs to the family Poaceae. It is a C4 plant, it has a highly efficient photosynthesis process. The plant produces large, narrow leaves and a solid stem. The kernels are the edible part of the maize and they develop from the fertilized ovules of the female flowers (Yasin, 2024). Maize is a versatile crop used for various purposes. It is a staple food in many countries, providing a significant portion of dietary energy and it is used as livestock feed, in the production of biofuels and in the manufacturing of various industrial products (Hernandez, 2019).

Maize originated from Mexico (Chumo, 2013) and was introduced to Africa through trade and is now cultivated in various regions of Zimbabwe, tailored to different varieties and regional weather conditions. The optimum conditions for maize production include a climate with temperatures ranging from 18 to 25 degrees Celsius and an average annual rainfall between 600 and 1200 mm (FAO, 2021). Maize favors well-drained fertile soils such as sandy loam and is typically grown on flat to gently sloping terrain at altitudes of 500 to 1500 meters above sea level (Chigombe, 2023)

Maize requires a range of nutrients for optimal growth. Fertilizer requirements for maize encompass both macro and micro-nutrients, including nitrogen, phosphorus, potassium, boron, and magnesium. These nutrients are essential for various physiological processes, such as chlorophyll production, root development, and overall plant health (Fageria, 2009). Maize is a wind-pollinated plant, ensuring genetic diversity and adaptability. It can be cultivated in both greenhouses and open fields, depending on the specific agricultural practices (Shiferaw et al., 2011).

Maize is a staple food in Zimbabwe, with a significant portion of the population relying on it for their daily caloric intake. However Zimbabwe's maize yield is relatively low compared to other countries. The average yield for the 2020/21 season was 1.39 tonnes per hectare, which is significantly lower than Zambia's 2.8 tonnes per hectare and South Africa's 5.8 tonnes per hectare (ZimFact, 2021). In the 2022/23 season, Zimbabwe produced approximately 2.3 million tonnes of maize, a 58% increase from the previous year. However, the yield for communal farmers remains low, averaging 0.84 tonnes per hectare. Large-scale commercial farmers achieve higher yields, averaging 4 tonnes per hectare (The Insider, 2022).

Despite an increase in production, Zimbabwe's yield remains below regional averages since it faces several challenges which includes drought and low fertilizer use. These factors contribute to low productivity and necessitate the importation of maize to meet the country's demand since most of the farmers do not have equipment and funds for supplementary irrigation. In Zimbabwe, there is adequate land for farming but one of the production hindrances is water shortage.

Agrisilica is a soil conditioner which can help to increase maize productivity by improving water retention and soil health. This is particularly important in drought-affected areas, where water retention can significantly impact crop yields (Guntzer, Keller & Meunier, 2012). It can also help communal farmers with low average yields at least to harvest the grain which will sustain their life

1.2 Problem statement

Maize is a staple food in Zimbabwe, providing essential nutrients and serving as a primary food source for approximately 80% of the population (FAO, 2017). However, despite its significance, maize productivity in Zimbabwe remains low which is a challenge, with average yields falling significantly below regional benchmarks. The average yield for communal farmers stands at 0.84 tonnes per hectare, while large-scale commercial farmers manage to achieve about 4 tonnes per hectare (The Insider, 2022). This low productivity is exacerbated by frequent droughts, limited access to high-quality fertilizers, and poor soil water retention, resulting in the need for maize importation to meet national demand (ZimFact, 2021).

1.3 Justification

At the end of this project, it will help farmers by providing actionable insights on how to enhance maize productivity through the use of Agrisilica as a soil conditioner. This will address critical challenges such as low yield, poor water retention, and the impact of drought on maize production in Zimbabwe.

Maize plays a pivotal role in the diet and economy of Zimbabwe. It is the primary source of calories for approximately 80% of the population (FAO, 2017). Given its importance, enhancing maize productivity is essential for food security and economic stability. However, maize yields in Zimbabwe are among the lowest in the region. This low productivity exacerbates food insecurity and necessitates costly maize imports (ZimFact, 2021). Zimbabwe frequently faces drought conditions that severely impact maize production for instance the drought of last season. Drought not only reduces crop yields but also affects soil moisture levels, leading to poor crop growth and reduced productivity. As climate change continues to exacerbate these conditions, it becomes increasingly important to adopt strategies that can mitigate the effects of water scarcity on crop production (Guntzer, Keller & Meunier, 2012). Agrisilica, a silicon-based fertilizer, has shown promise in improving plant water retention and reducing transpiration rates. Silicon helps plants cope with abiotic stresses such as drought by strengthening cell walls, improving water use efficiency, and enhancing overall plant resilience (Epstein, 1999). By incorporating Agrisilica into maize cultivation, it is possible to improve water retention in the soil, thus supporting maize growth even under conditions of moisture stress. Improving maize productivity through the use of Agrisilica and Compound D could have significant economic and social benefits. Increased maize yields would reduce the need for imports, thereby saving foreign exchange and stabilizing local markets. Moreover, higher productivity would lead to improved food security, better livelihoods for farmers, and overall economic growth (Pingali & Pandey, 2001).

1.4 Main objective

The main objective of this project is to determine the effects of Agrisilica on maize growth rate, water retention, and yield in order to enhance maize productivity and sustainability in drought-prone regions of Zimbabwe.

1.4.1 Specific Objectives

1. To determine the impact of Agrisilica on the growth rate of maize plants under 2 varieties.
2. To measure the effectiveness of Agrisilica on soil water retention improvement in maize plants under 2 varieties.

3. To measure the effect of Agrisilica on maize yield under 2 varieties at physiological maturity.

1.5 Hypotheses

1. Use of Agrisilica significantly improves the growth rate of maize plants under 2 varieties.
2. Use of Agrisilica significantly improves soil water retention in maize plants under 2 varieties.
3. Use of Agrisilica significantly improves maize yield under 2 varieties.

CHAPTER 2: LITERATURE REVIEW

2.1 Origin of maize

Maize scientifically known as Zea *mays* is one among the mostly cultivated crops globally and it serves as a primary source of food, feed and industrial raw material. Most scientists agree that maize originated from in Central America (Mexico) over approximately 7000 years ago. (Benz.et.al 2001)It was domesticated from a wild grass called teostine which look like the ,modern maize and then it was domesticated by early farers in Mexico by selecting the biggest and best kernels until the crop we are recognizing today over 7000 years ago. It widely spreads and become a staple crop in many continents including Africa because of its nutritious and easy production (www.brightmaize.com)

2.2 Climatic, soil and nutritional requirements of maize

According to Seedco maize growers guide, maize grows well on deep well drained, fertile soils with an average rainfall that exceeds 500mm. It is a bit tolerant to acidity but if the soil is too acidity liming will improve its production. Maize is susceptible to drought and water logging so poorly drained soils should be avoided. Drought during the 4 weeks of silking and tasselling may lead to serious yield losses .Maize favours optimum temperatures (18-25 degrees) since very high temperatures affects pollen viability and very low temperatures slows growth rate (Rahman, 2021).

Maize requires a range of nutrients for optimal growth. Fertilizer requirements for maize encompass both macro and micro-nutrients, including nitrogen, phosphorus, potassium, boron, and magnesium. These nutrients are essential for various physiological processes, such as chlorophyll production, root development, and overall plant health (Fageria, 2009). It can be cultivated in both greenhouses and open fields, depending on the specific agricultural practices (Shiferaw et al., 2011).

2.3 Overview of maize production in Zimbabwe

In Zimbabwe, maize production plays a pivotal role on the economy of Zimbabwe and it is the primary food source to an extent that about 80% of the people rely on sadza as a staple food. It is grown both at small and large scale. With its importance, enhancing its productivity is essential however, Zimbabwe is among the lowest regions with an average of 0.84 tonnes per hectare on communal farmers and 4 tonnes per hectare for large scale farmers (Rukuni, 2023) and this is due to a number of reasons which includes biotic and abiotic stress that might include drought, pest and disease and infertile soils (Madzivanzira, 2024).

Maize is Zimbabwe's most important cereal crop and a national staple, it's a backbone of food security and rural livelihood and also contributes to household food consumption, livestock feed and national grain reserves. Maize plays a vital role in employment creation and agro-industry supply chain that is milling, poultry and livestock sectors (FAO, 2022). The crop accounts for over 50 % of the country's caloric intake and it is cultivated by more than 90% of communal farmers, making it central to Zimbabwe food system (Moyo et al, 2021).

Zimbabwe grows both open pollinated (OPVs) and hybrid varieties maize varieties. OPVs are drought tolerant and allow seed retention, which benefits small holder farmers (CIMMYT, 2020). In contrast, hybrid varieties like SC555, SC513 and SC627are high yielding and more responsive to fertilizers but require annual seed purchases. The government and research institutions like SeedCo have made efforts to develop maize varieties suited for different agro-ecological regions (Chikowo et al., 2023).

Major maize producing agents in Zimbabwe are region I to III, where rainfall and soils are more favourable .Region II which includes areas like Mashonaland central, east and west, is the maize production hub due to its high rainfall (750 to 1000mm annually) and deep fertile soils (Vincent and Thomas, 1960). Region IV and V which cover parts of Matebeleland and southern provinces, are areas of low rainfall which is less than 650mm and poor soils making maize production more marginal and risk (AGRITEX, 2022).

2.4 Use of Agrisilica in maize production

Agrisilica, a granular silicon-based fertilizer (2–5 mm in particle size), offers a sustainable solution to enhancing agricultural productivity. Characterized by its off-white appearance, it exhibits an impressive carbon exchange capacity exceeding 30 cmol/kg (FSG Superfert Company, 2025). Manufactured in Zimbabwe by FSG Superfert Company, Agrisilica's soluble silicon content is

26%, ensuring optimal bioavailability for plant uptake—a critical factor in its efficacy (FSG Superfert Company, 2025). With a bulk density of 900 g/kg when loosely packed and a moisture retention capacity below 12%, Agrisilica aligns with rigorous quality standards (Agronomic Research Institute, 2024).

Upon application, Agrisilica releases silicon into the soil in the form of monosilic acid, a bioactive compound, over a period of approximately eight weeks (Agronomic Research Institute, 2024). The recommended application rate is 25 kg per acre, and the product is compatible with all fertilizers, promoting versatility in integrated nutrient management systems (FSG Superfert Company, 2025). Agrisilica plays a multifaceted role in regulating biochemical pathways, optimizing protein synthesis, and enhancing nutrient uptake efficiency. Additionally, it mitigates the toxic effects of heavy metals on plants and soil, induces systemic resistance against pathogens, and fosters improved crop development and yield performance (Agronomic Research Institute, 2024; FSG Superfert Company, 2025).

Agrisilica, it is an essential fertilizer which consist of a metalloid element silicon and it is available to the plants as orthosilic acid in small amount in the soil which is absorbed by the plant roots (Tayade et al. 2002), if exogenously applied on several plants it has got advantageous effects on plants including vegetative growth and development, production and reduction of biotic and abiotic stresses (Zargar et al, 2019). According to Amin et al 2015, silicon fertilizers modulate plant growth and development and improves crop tolerance to abiotic stress and application of silicon increases plant height, cob length, leaf area index and related attributes with stimulates photosynthesis rate under limited water environment. Application of silicon on drought stressed maize lowers transpiration rate (Ali et.al 2015). Tunal et al recommended exogenous application of silicon as a supplement to maize nutrient requirements especially to plants subjected to salt affected soils and the utilization of silica fertilizers results in increased plant growth, higher productivity, protection against pathogens and adaptation to unfavourable environmental conditions (Thakral et al., 2021 and Rao et al., 2017)

Silicon fertilization is an important factor which improve crop yield and it capacitates crops with resilience to improve crop yield and endure future limitations and its inclusion in modern agriculture has to be considered in large scales to adapt crops to the current challenges of sustainable agriculture and food provision. In a study on sugarcane the application of silicon increased concentration of all other nutrients nitrogen, potassium, phosphorus and other micronutrients and sugarcane parameters showed positive relationship with silicon leading to the height, stalk diameter and the dry leaf biomass to increase and it was 50, 58 and 71 % higher compared to control plants without silicon and also stalk borer damage was significantly reduced due to the accumulation of silicon (Olivia et al 2021). On plants applied silicon it blocks the apoplastic entry route of toxicants through the casparian strip (Fleck et al 2015) and when silicon is translocate to the leaves it is deposited on the cell walls forming a thick layer which will be a barrier in blocking entry of pathogens and it also modulates reactive oxygen species level leading to detoxification and reduction of stress effect and increased plant growth (Gong et al 2006). According to Rasoolizadeh et al 2018 discovered that silicon in plants forms a barrier layer in the apoplast region which disrupts establishment of specificity between an insect and plant by changing the flow of molecules for example effectors and it helps plant to prevent piercing and sucking pest due to limited translocation and release of effectors in plants applied silicon.

Fertilizer are critical to the food supply globally and farmers utilize commercial chemical fertilizers to meet current need of a plant and agrisilica has to be included (Purbajantiet al 2019) since it has got positive effects on plant essential nutrients and it has a dual effect on the plant system and it also optimises soil fertility through improved water, physical and chemical properties of the soil and it maintains nutrients in plant available form and on average it increases the yield by 10 to 25% (bocharnikova et al). Wlodarczyk et al. (2019) reported that silicon was applied to barley under flooding conditions and it reduced the intensity of oxidative damage without any significant change in the antioxidant activity.

Research conducted up to now tell us that silicon is very important element to help crops cope with and limitations and other attacks. It is also stated that also non silica accumulator species crops can also benefit from the silica presence and even where there is no stress silica improves growth (Besharat et al. 2020). Application of silica fertilizer improves soil fertility, crop needs, soil moisture patterns, and crop nutrient uptake from soil and also help nutrient ratio maintenance withdrawn by crops in checks (Zargar et al. 2019). Ali et al. (2021) indicated that under water deficit condition in maize plants (applied silicon fertilizer) tend to close their stomata to reduce transpiration water loss and thus avoiding deficit on soil moisture (Seiler et al., 2014).

However, there is need to increase field experiments for crops with experiments done in labs or greenhouses and have returned good results. There is need to increase dissemination of projects to show farmers that addition of silica to the soil brings ore income through improved yields while making crops more resilient to present and future limitations since any farmers are struggling with adaptation techniques to abiotic and biotic stress and making farmers aware of new solutions which makes silica research significant (Leishman, 2016).

All these studies where not done in Zimbabwe and this leaves a knowledge gap to farers if agrisilica can really attain its best activity with positive effects and farmers in Zimbabwe are not fully aware of the agrisilica fertilizer which have got positive influence on maize crop they are only aware on well-known fertilizers like compound D and ammonium nitrate and they are ignorant on agrisilica supplement fertilizer which hastens the crop growth, soil health, pest resistance, water stress and growth rate. Researches which were undertaken on application of silicon on maize there was use of varieties which are not local to our farmers so by the use of local varieties, local soils under local environmental conditions will help farmers in addressing some of the problems encountered on maize production like drought and low yields (Musvaire and Makanda, 2023).

CHAPTER 3: METHODOLOGY

3.1 Experimental Site

The experiment was conducted on Superfert Bindura Demonstration Land, which is renowned for its agricultural research and development activities. The demonstration land is under agro-ecological zone IIa and it is located in Bindura, Zimbabwe. The GPS coordinates for the site are latitude: -17.3020, longitude: 31.3306**.** Directions from the capital city, Harare, travel north on the A11 highway (Bindura road) for approximately 88 kilometers to reach Bindura. The Superfert Bindura Demonstration Land is situated on the outskirts of Bindura, easily accessible from the main road along Trojan road. The demonstration land contains sandy loam soils and its pH ranges from 6 to 7.5 with an altitude of 1100 metres above sea level.

3.2 Experimental Design

The experiment was a 2*4 Factorial treatment structure laid in a Randomized Complete Block Design (RCBD) with 8 treatments replicated 3 times to give a total of 24 experimental units (plots). The first factor was variety which had 2 levels (SC 555 and SC 657) while the second factor was basal fertilizer type which had 4 levels (Agrisilica, Compound D, Agrisilica + Compound D and Control/no fertilizer). Soil type was used as the blocking factor to minimize variability due to soil heterogeneity. Random number table was used to allocate the different treatments to plots within the 3 blocks. The treatments are illustrated on Table 3.1 below:

Table 3.1: Research treatments

	TREATMENT	DESCRIPTION
1	V1T1	SC 555 under Agrisilica alone
2	V1T2	SC 555 under Compound D alone
3	V1T3	SC 555 under Combination of agrisilica and compound D

4	V1T4	Control (SC 555 under no agrisilica or compound D)
5	V2T1	SC 657 under Agrisilica alone
6	V2T2	SC 657 under Compound D alone
7	V2T3	SC 657 under Combination of agrisilica and compound D
8	V2T4	Control (SC 657 under no agrisilica or compound D)

Two maize varieties V1 (SC 555) and V2 (SC 657) were used in the experiment to compare the effects of the treatments on different genetic backgrounds. The field layout of the experiment is illustrated on Table 3.2.

Table 3.2: Experimental field layout

BLOCK 1	**Plot 1**	**Plot 2**	**Plot 3**	**Plot 4**	**Plot 5**	**Plot 6**	**Plot 7**	**Plot 8**
	V1T1	V1T3	V2T1	V1T2	V1T4	V2T2	V2T4	V2T3
BLOCK 2	**Plot 9**	**Plot 10**	**Plot 11**	**Plot 12**	**Plot 13**	**Plot 14**	**Plot 15**	**Plot 16**
	V2T4	V2T1	V1T1	V2T2	V1T3	V1T2	V2T3	V1T4
BLOCK 3	**Plot 17**	**Plot 18**	**Plot 19**	**Plot 20**	**Plot 21**	**Plot 22**	**Plot 23**	**Plot 24**
	VIT3	V2T3	V1T4	V2T1	V1T1	V1T2	V2T4	V2T2

3.3 Agronomic practices

3.3.1 Land Preparation:

- The experimental plots were prepared by ploughing and harrowing to create a fine tilth suitable for maize planting.
- Plot sizes were standardized to ensure uniformity across treatments.

3.3.2 Planting:

- Maize seeds were sown at a spacing of 75 cm between rows and 25 cm within rows.
- Two seeds per hill were planted and later thinned to one plant per hill to achieve the desired plant population.

3.3.3 Fertilization:

- The Agrisilica and Compound D fertilizers were applied according to the treatment specifications.
- Both were applied as basal fertilizer at planting, with Compound D applied at planting at a rate of 300 kg/ha while Agrisilica was applied at a rate of 500 kg/ha.

3.3.4 Weed Management:

- Weeding was carried out manually to ensure weed-free conditions throughout the growing season.
- The first weeding occurred two weeks after planting, followed by subsequent weeding as necessary.

3.3.5 Irrigation:

- No irrigation was supplemented even during dry spells. We only relied on natural rainfall

3.3.6 Pest and Disease Control**:**

- Regular monitoring for pests and diseases was conducted.
- Appropriate chemical and cultural control measures were implemented to manage any pest or disease outbreaks.

3.4 Data Collection:

- Data on maize growth rate, water retention, and yield quantity was collected periodically.
- Growth rate was measured by recording plant height at 2 weeks interval from week 3 after planting.
- Water retention was assessed by soil moisture content measurements.

- Yield quantity was determined by harvesting and weighing the maize cobs at physiological maturity.

3.5 Data Analysis

The data on maize growth rate, water retention and yield quantity were subjected to analysis of variance (ANOVA) using GenStat statistical package. The least significant difference (l.s.d) was used for mean separation at 0.05 probability level. The data were analyzed using a two-way factorial ANOVA model specified as:

$$Y_{\{ijk\}} = \mu + V_j + A_k + (V \times A)_{\{jk\}} + \varepsilon_{\{ijk\}}$$

where *Yijk* is the observed value for the response variable (growth rate, water retention, or yield), μ is the overall mean, *Vj* is the fixed effect of the j-th maize variety, *Ak* is the fixed effect of the k-th fertilizer treatment, *(V × A)jk* is the interaction between variety and fertilizer treatment, and *εijk* is the random error term.

CHAPTER 4: DATA ANALYSIS & RESULTS

4.1 Effect of variety and fertilizer on maize growth rate

Basal fertilizer type had a highly significant effect ($p < 0.001$) on growth rate of maize plants, with all fertilized treatments significantly improving growth rate compared to the control. Plants with agrisilica, compound D and with both agrisilica and compound D had taller plants than the control. The plant height was highest in maize with agrisilica and compound D (Figure 4.1). However, variety had no significant effect ($p>0.05$) on maize growth rate in terms of plant height. Moreover, there was no significant interaction ($p>0.05$) of variety × fertilizer application on maize plant height.

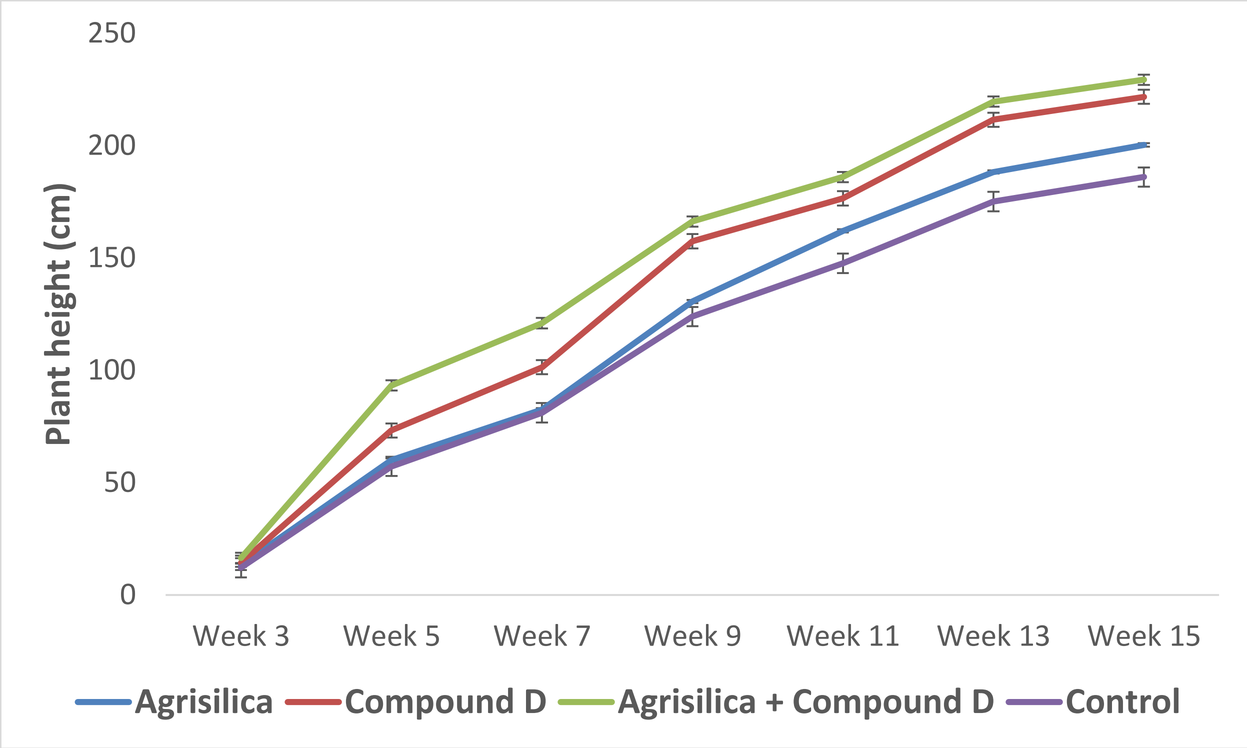

Figure 4.1: Effect of basal basal fertilizer type on maize growth rate

4.2 Effect of variety and basal fertilizer type on water retention

Variety had significant effect ($p = 0.001$) on water retention, with SC 555 exhibiting better water retention of 47.0–54.0% compared to SC 657 which had 41.7–52.0% (Table 4.1).

Table 4.2: Effect of Variety on Maize Yield (kg/ha)

Variety	**Water retention (%)**
SC 555	48.5^{a}
SC 657	46.4^{b}
Grand mean	47.4
Fprob	0.001
l.s.d	8.9
Cv%	3.2%

Basal fertilizer type had a highly significant effect ($p < 0.001$) on water retention, with all fertilized treatments improving water retention compared to the control. The Agrisilica + Compound D combination resulted in the highest water retention for both maize varieties followed by Compound D and Agrisilica. The control treatment shows the lowest water retention (Figure 4.2). However, there was no significant interaction ($p>0.05$) of variety × fertilizer application on water retention.

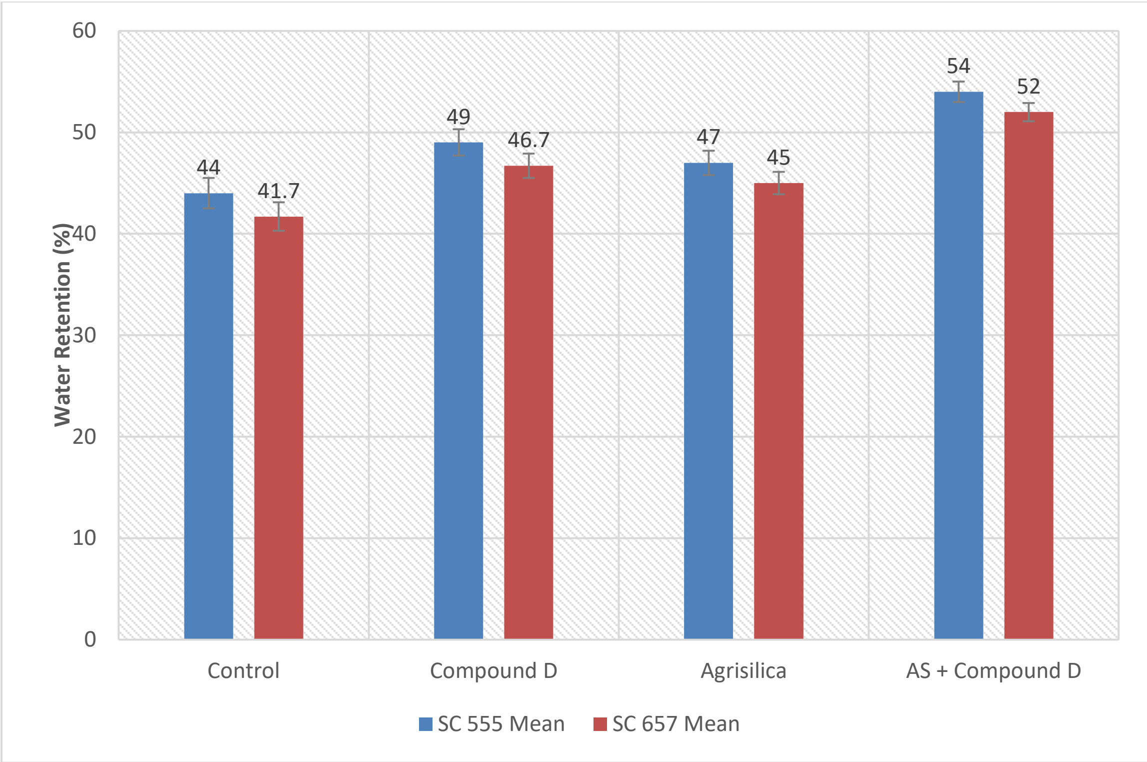

Figure 4.2: Effect of basal fertilizer type on water retention

4.3 Effect of variety and fertilizer type on yield

Variety had a significant effect ($p < 0.008$) on the maize yield, with SC 555 producing a higher mean yield of 551.7 kg/ha compared to 525.0 kg/ha for SC 657 (Table 4.1).

Table 4.1: Effect of Variety on Maize Yield (kg/ha)

Variety	**Yield (kg/ha)**
SC 555	551.7[a]
SC 657	525.0[b]
Grand mean	538.4
Fprob	0.008
l.s.d	5.2
Cv%	3.8%

Basal fertilizer type also had a highly significant effect ($p < 0.001$) on yield. All fertilized treatments significantly outperformed the control. The combination of Agrisilica + Compound D resulted in the highest yields across both varieties (Figure 4.2). However, there was no significant interaction ($p>0.05$) of variety × fertilizer application on maize yield.

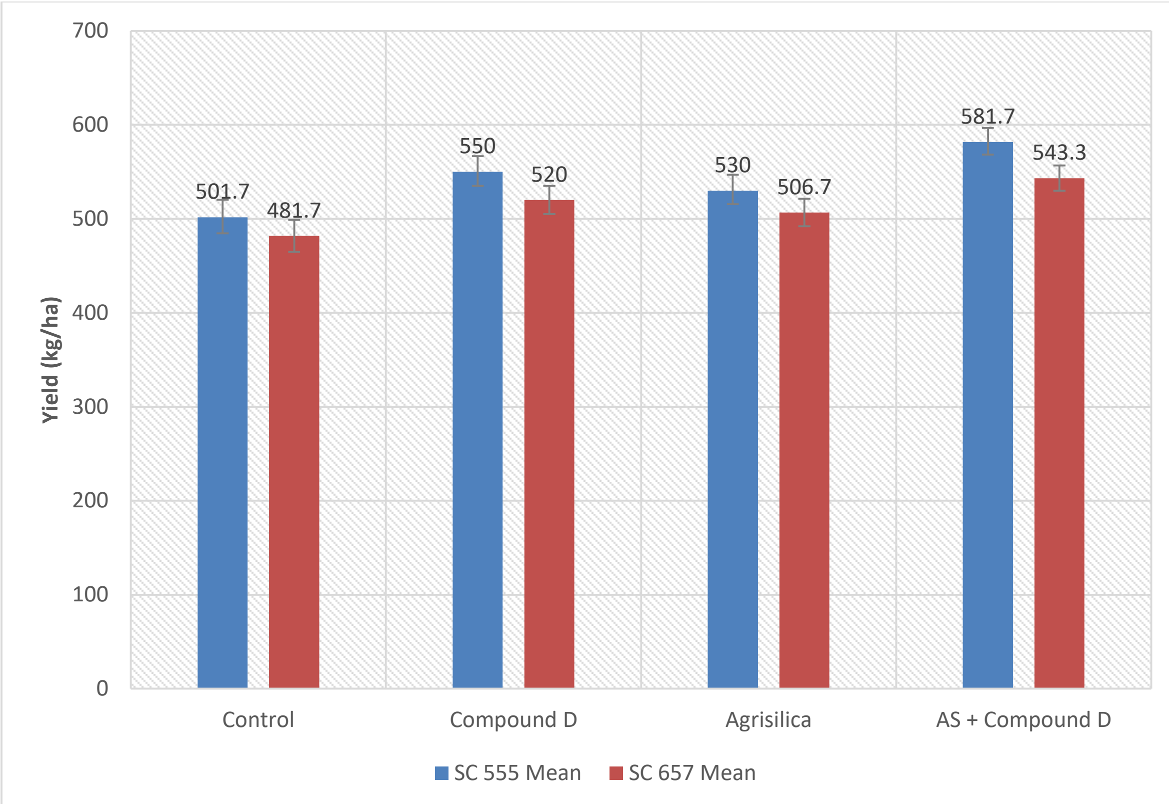

Figure 4.5: Effect of basal fertilizer type on plant yield (kg/ha).

CHAPTER 5: DISCUSSION

5.1 Impact Effect of variety and basal fertilizer type on maize growth rate

The study results clearly show that the application of Agrisilica, alone or in combination with Compound D, significantly enhances the growth rate of maize plants during the growing season. According to the factorial ANOVA results, fertilizer treatment had a highly significant effect ($p < 0.001$), confirming that fertilizer type greatly influences plant growth.

The treatment combining Agrisilica and Compound D produced the highest weekly growth rates. In contrast, the control group recorded the lowest rates. This indicates that the use of silicon-enriched fertilizers like Agrisilica provides a notable advantage in boosting vegetative development. Research by Tayade et al. (2022) supports this observation, concluding that silicon application improves plant cell wall integrity, water uptake, and photosynthesis, all of which contribute to higher biomass accumulation and faster growth rates. Agrisilica, which is rich in plant-available silicon, enhances the physiological functions necessary for vigorous plant development.

Additionally, Mandal et al. (2022) found that the application of silicon in maize improved physiological performance and yield under water-limited conditions. These findings reinforce the idea of appropriate soil amendment such as Agrisilica and Compound D can significantly enhance crop performance. Notably, the narrow error bars and tight interquartile ranges observed within Agrisilica-treated groups confirm the treatment's consistency, supporting its reliability as a growth enhancer in early maize development.

5.2 Effect of variety and basal fertilizer type on water retention

The study revealed that Agrisilica application significantly enhanced soil water retention in maize plots compared to the control and Compound D-only treatments. The factorial ANOVA results confirmed that the type of treatment had a statistically significant impact on soil moisture levels ($p < 0.001$), with a large effect size ($\eta^2 = 0.832$), indicating that Agrisilica notably improved the soil's capacity to retain moisture throughout the growing season.

Plots treated with Agrisilica either alone or combined with Compound D consistently maintained higher soil moisture percentages during critical growth stages, such as tasseling and grain filling. This improvement is particularly valuable in semi-arid regions where maize cultivation is often limited by inconsistent rainfall and rapid moisture loss. Agrisilica appears to contribute by improving the soil structure and increasing its water-holding capacity. These findings are in agreement with Amin et al. (2014), who reported that silicon application in maize under water-deficit conditions improves root morphology and enhances water uptake efficiency, leading to increased tolerance to drought stress and better soil moisture retention. Similarly, Islam et al. (2022) noted that silicon-treated soils demonstrated improved porosity and reduced evapotranspiration losses, resulting in prolonged water availability to crops under dry conditions.

In this study, the combined application of Agrisilica and Compound D not only resulted in higher water retention but also demonstrated greater consistency in soil moisture measurements, as evidenced by narrower standard error margins across replicates. This consistency suggests that silicon-based treatments improve not just average performance but also the predictability of outcomes, a critical factor in agricultural management. These results are supported by previous studies showing that silicon fertilization enhances soil moisture status and plant resilience under drought conditions. For instance, Kumar et al. (2023) highlighted that silicon contributes significantly to soil water retention and stress tolerance in cereals like rice, acting as a beneficial soil conditioner that improves long-term soil health and crop productivity. Similarly, Yahya (2024) found that the interactive use of silicon and zinc improved drought resistance in wheat by maintaining higher soil moisture and supporting plant physiological functions under water-deficit conditions. The enhanced moisture retention observed in the Agrisilica-treated plots in our trial reinforces the value of silicon-based fertilizers in climate-sensitive cropping systems such as maize, particularly by improving both hydration and system reliability for farmers.

5.3 Effect of variety and fertilizer type on yield

The study findings demonstrate a significant increase in maize yield at physiological maturity in plots treated with Agrisilica, particularly when applied in combination with Compound D. The results from the factorial ANOVA showed that fertilizer treatment had a highly significant impact on final grain yield ($p < 0.001$), with a large effect size ($\eta^2 = 0.841$), confirming the critical role of silicon-based supplementation in improving maize productivity.

The combined treatment (Agrisilica + Compound D) recorded the highest mean yield for both varieties, with SC 555 producing 8.9 t/ha and SC 657 yielding 8.3 t/ha. These yields were significantly higher than those from the control group, which recorded 6.1 t/ha for SC 555 and 5.7 t/ha for SC 657. This outcome suggests that silicon not only supports growth but also plays a pivotal role in final biomass and grain filling. According to Biswas and Islam (2024), silica nanoparticles improve crop yield by enhancing nutrient uptake, promoting enzymatic activity during reproductive stages, and reducing lodging, all of which contribute to better kernel development and weight.

Another plausible reason for the improved yield is the positive influence of silicon on drought resilience and water use efficiency, which supports sustained growth during stress periods. Mabagala et al. (2020) also observed that silicon application in maize enhanced nitrogen use efficiency and improved biomass partitioning to reproductive organs, ultimately boosting grain yield under both optimal and stress conditions. Moreover, the lower yield variation among replicates in Agrisilica-treated plots as shown in the reduced standard error indicates not only higher yields but also consistency. These findings support the integration of silicon-based inputs like Agrisilica into maize fertilization programs, especially in semi-arid zones where yield stability is critical.

CHAPTER 6: CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

This study aimed to evaluate the effects of Agrisilica, both individually and in combination with Compound D, on maize growth rate, soil water retention, and yield quantity at physiological maturity. The results provide strong evidence that silicon-based fertilizer interventions can significantly improve crop performance under semi-arid conditions.

Firstly, the application of Agrisilica and Compound D significantly enhanced the growth rate of maize, with the combined treatment yielding the highest weekly growth increments. Secondly, Agrisilica treatments improved soil water retention substantially. The enhanced moisture levels in treated plots are attributed to the structural benefits silicon imparts to soil, improving its porosity and reducing evapotranspiration. This finding is crucial for maize farming in water-limited environments, where efficient water use is vital for sustaining crop productivity. Finally, the study showed that yield quantity at physiological maturity was significantly higher in plots treated with Agrisilica, especially when combined with Compound D. The increased grain yield can be linked to improved nutrient use efficiency, better water retention, and stronger vegetative growth throughout the season. The reduced variability in treated plots further highlights the consistency and reliability of Agrisilica in enhancing yield outcomes.

Overall, the integration of silicon-based fertilizers like Agrisilica into maize production systems offers a promising strategy for improving crop performance, especially in regions vulnerable to water stress. The findings support the broader use of silicon as a functional nutrient that not only strengthens plant structure but also enhances productivity and resilience. Future studies could explore long-term soil health impacts and cost-effectiveness for broader adoption in smallholder farming systems**.**

6.2 Recommendations

Based on the findings of this research, the following recommendations are proposed to guide agricultural practices, policy formulation, and future research on maize production using silicon-based fertilizers:

6.2.1 Adoption of Agrisilica in maize production

- Farmers in semi-arid and drought-prone areas are strongly encouraged to integrate Agrisilica into their maize fertilization regimes since Agrisilica significantly enhances maize growth rate, improves soil moisture retention, and increases final grain yield. Its use should be prioritized in areas facing water scarcity or unpredictable rainfall patterns.

6.2.2 Use of combined fertilizer treatments for maximum yield

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- Extension officers and agronomists should promote combined application of Agrisilica and Compound D among smallholder and commercial farmers for optimal productivity in maize production.

6.2.3 Variety selection matters

- Maize variety SC 555 showed greater responsiveness to Agrisilica and should be prioritized where rapid growth and high yields are desired on semi-arid conditions.
- Farmers should be advised to choose varieties based on their compatibility with silicon-based inputs, as varietal differences significantly affect treatment outcomes.

6.2.4 Water management strategy

- Agrisilica enhances the soil's water-holding capacity. Therefore, its use should be integrated into drought mitigation strategies in maize-based farming systems.
- Policymakers and agricultural advisors should include silicon-based fertilizer programs in climate resilience policies and irrigation planning.

6.2.5 Further research and trials

- It is recommended that long-term field trials be conducted to evaluate the residual effects of Agrisilica on soil health, fertility, and microbial activity.
- Economic analysis of input cost vs. yield gains should also be carried out to assess the cost-effectiveness and return on investment for farmers.
- Trials should also explore the performance of Agrisilica under different soil types and across additional maize varieties.

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APPENDICES

Appendix 1: Analysis of variance (ANOVA) Tables

Appendix 1.1: Analysis of variance for plant height (cm) at week 3

Source of variation	d.f.	s.s.	m.s.	F. value	F pr.
Block	2	11.556	5.778	3.78	
Fertilizer	3	61.655	20.552	13.45	<.001
Variety	1	0.700	0.700	0.46	0.509
Fertilizer × Variety	3	4.021	1.340	0.88	0.476
Residual	14	21.398	1.528		
Total	23	99.330			

Appendix 1.2: Analysis of variance for plant height (cm) at week 5

Source of variation	d.f.	s.s.	m.s.	F. value	F pr.
Block	2	328.81	164.41	5.49	
Fertilizer	3	4853.79	1617.93	54.01	<.001
Variety	1	15.52	15.52	0.52	0.484
Fertilizer × Variety	3	30.01	10.00	0.33	0.801
Residual	14	419.41	29.96		
Total	23	5647.55			

Appendix 1.3: Analysis of variance for plant height (cm) at week 7

Source of variation	d.f.	s.s.	m.s.	F. value	F pr.
Block	2	89.26	44.63	2.79	
Fertilizer	3	6343.26	2114.42	132.42	<.001
Variety	1	50.75	50.75	3.18	0.096
Fertilizer × Variety	3	45.27	15.09	0.94	0.446
Residual	14	223.73	15.98		
Total	23	6753.28			

Appendix 1.4: Analysis of variance for plant height (cm) at week 9

Source of variation	d.f.	s.s.	m.s.	F. value	F pr.
Block	2	719.48	359.74	6.4	
Fertilizer	3	7554.08	2518.03	45.09	<.001
Variety	1	152.51	152.51	2.73	0.121
Fertilizer × Variety	3	109.40	36.47	0.65	0.594
Residual	14	781.86	55.85		
Total	23	9317.33			

Appendix 1.5: Analysis of variance for plant height (cm) at week 11

Source of variation	d.f.	s.s.	m.s.	F. value	F pr.
Block	2	109.91	54.96	1.45	
Fertilizer	3	5082.26	1694.09	44.74	<.001
Variety	1	119.71	119.71	3.16	0.097
Fertilizer× Variety	3	33.48	11.16	0.29	0.829
Residual	14	530.12	37.87		
Total	23	5875.47			

Appendix 1.6: Analysis of variance for plant height (cm) at week 13

Source of variation	d.f.	s.s.	m.s.	F. value	F pr.
Block	2	4.10	2.05	0.07	
Fertilizer	3	7600.25	2533.42	87.28	<.001
Variety	1	5.90	5.90	0.20	0.659
Fertilizer × Variety	3	5.80	1.94	0.07	0.977
Residual	14	406.37	29.03		
Total	23	8022.45			

Appendix 1.7: Analysis of variance for plant height (cm) at week 15

Source of variation	d.f.	s.s.	m.s.	F. value	F pr.
Block	2	5.00	2.50	0.06	
Fertilizer	3	7056.39	2352.13	52.56	<.001
Variety	1	13.50	13.50	0.30	0.592
Fertilizer × Variety	3	6.26	2.09	0.05	0.986
Residual	14	626.56	44.75		
Total	23	7707.71			

Appendix 1.8: Analysis of variance for water retention

Source of variation	d.f.	s.s.	m.s.	F. value	F pr.
Block	2	322.582	107.527	557.38	
Fertilizer	3	322.582	107.527	557.38	<0.001
Variety	1	9.375	9.375	4.86	<0.001
Fertilizer × Variety	3	0.115	0.038	0.2	0.896
Residual	16	3.087	0.193		
Total	23	335.159			

Appendix 1.9: Analysis of variance for maize yield kg/ha

Source of variation	d.f.	s.s.	m.s.	F. value	F pr.
Block	2	322.582	107.527	557.38	
Fertilizer	3	322.582	107.527	557.38	<0.008
Variety	1	9.375	9.375	4.86	<0.001
Fertilizer × Variety	3	0.115	0.038	0.2	0.896
Residual	16	3.087	0.193		
Total	23	335.159			

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