BINDURA UNIVERSITY OF SCIENCE EDUCATION

FACULTY OF AGRICULTURE AND ENVIRONMENTAL SCIENCE
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Evaluation of the performance of determinate (Rodade, Tengeru) and Indeterminate (Star 9037, Candella) tomato varieties open field management.

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A Dissertation Submitted in Partial Fulfilment of the Bachelor of Science Honours in Crop Science Degree.

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DECLARATION

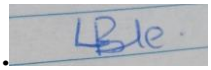
BINDURA UNIVERSITY OF SCIENCE EDUCATION

FACULTY OF AGRICULTURE AND ENVIRONMENT SCIENCE

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

Evaluation of the performance of determinate (Rodade, Tengeru) and indeterminate (Star9037, Candela) tomato variety on open field management.

I, Bonde Lynn Rudo hereby declare that this research project is the result of my original work that had been researched and got submitted on fulfilment of the Bachelor of Agricultural Honours Degree Majoring in Crop Science at Bindura University of Science Education.

BONDE LYNN R. **…….**  **…….**

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DEDICATION

This dissertation is dedicated to my family for their moral and financial support throughout the whole programme.

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ABSTRACT

In Zimbabwe, tomato production is crucial for smallholder famers, but the yields remain low due to challenges in selecting suitable varieties for specific agro-ecological conditions. The study evaluated the performance of determinate (Rodade, Tengeru) and indeterminate (Star9037, Candela) tomato variety on open field management. Stem height, stem thickness, biomass and final yield, were measured over a six-week period. The experiment was conducted at Nyakudya farm in Mashonaland central, structured as a completely randomised design involving four treatments (Rodade,Tengeru,Star9037 and Candella) replicated three times to make twelve plots. Statistical analysis was performed using ANOVA in GenStart. There results obtained showed significant difference, the indeterminate varieties were taller whereas the Rodade was significantly shorter. In terms of stem thickness, the results revealed no significant differences among all varieties. This present similar stem robustness across both growth habits. On biomass accumulation differed significantly, determinate varieties (Rodade and Tengeru) outperforming indeterminate ones. Although the differences in final yield were not statistically significant, Rodade and Tengeru recorded higher numerical yields. Determinate varieties, especially the Rodade and Tengeru, demonstrated superior performance in biomass and practical field adaptability, making them suitable for short-season production under open-field management. Farmers that are aiming for higher vegetative growth and simplified field management should select determinate varieties, while indeterminate types may still be suitable for the extended harvest system.

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CHAPTER 1: INTRODUCTION

1.1 Background

Tomato (*Lycopersicon esculentum)* is thought to have originated in the South American Andes but its use as a meal began in Mexico and expanded around the world followed by the Spanish colonization of the Americas (Peralta, 2005; Jacobsen *et al*., 1994).Because it contains a few calories and is a source of minerals, vitamin A, and vitamin C, tomatoes may help maintain a healthy, well-balanced diet. Tomatoes also offers trace levels of the vitamin B complex, which includes niacin, riboflavin, and thymine. Cooked tomato and tomato products are the best source of lycopene since it is released from tomato when cooked. About 20% of the lycopene content of cooked tomatoes is present in raw tomatoes. The bright colour of tomato stimulates appetite and is very digestible (Sainju and Dris, 2006).

According to Mudzengi *et al*., (2019) tomatoes are grown throughout Zimbabwe, mostly in the provinces of Mashonaland west, Midlands, and Mashonaland east. The demand for tomatoes in Zimbabwe is very high, due to domestic consumption and export markets (Chitamba, 2016). According to Mashingaidze, (2005) also the 1990s saw a significant growth in the tomato industry in Zimbabwe, which was driven by increased demand from both domestic and export markets. Today, tomato production is seen as an important component in agricultural sector containing thousands of smallholder farmers in Zimbabwe.Mushonjowa *et al*., (2017) states that tomatoes are basically grown and consumed horticultural crops for both small holder and the large-scale farmers. The crop is frequently grown by smallholder farmers in search of income, accounting over 70% of the country tomato production (Chitamba, 2016).

There are determinate and indeterminate varieties grown in Zimbabwe, which have different growth habits. The determinate tomatoes, such as Tengeru and Rodade have a bushy growth habit, with a compact and upright plant structure. Patel (2018) states that determinate grow to a fixed height, typically ranging from 60-120cm and then stop growing. They produce fruit once with a single large harvest and mature earlier within 60-90days of transplanting. Indeterminate tomatoes, such as candela and star 9037 have a vining growth habit, with long, trailing stems that require staking or caging to support. They continue to grow, produce fruit continuously and require more complex pruning techniques to control their growth and promote fruiting (Patel *et al*., 2018). They mature 70-85 days.

Zimbabwe's tomato production has fluctuated over the years. In 2022, the country produced 26.39 million kilograms of tomatoes, representing a 0.66% decrease from the previous year (Food and Agriculture Organisation, 2022).Furthermore, tomato production has been on a decline in Zimbabwe due to low yielding varieties, drought and water scarcity, limited access to technology and extension services, pest and diseases outbreaks, lack of market and climate change. Small holder farmers are experiencing a problem in controlling pest and diseases, such as the tomato spotted wilt virus and bacterial wilt (*Ralstonia solanacearum*),resulting in reduced the growth rate and tomato yields (Mushonjowa *et al*.,2017;Patel *et al*.,2018).With numerous tomato varieties available, smallholder farmers are finding it challenging to select the most suitable variety for their specific needs and conditions (Chitamba,2016).However, tomato growth is highly dependent on a harmonious balance of temperature, soil conditions, and sunlight, which collectively define the agro ecological suitability of an area for successful tomato production (Heuvelink, 2005).

1.2 Problem of statement

Smallholder farmers in Zimbabwe are experiencing low yields due to challenges in selecting suitable varieties for specific agro-ecological conditions. Despite the availability of determinate and indeterminate tomato varieties, farmers lack access to improved, high yielding and limited information leading to reduced productivity and poor growth performance. Therefore, there is need to evaluate and identify tomato varieties with superior growth, biomass and yield to guide varietal selection and enhance productivity among smallholder farmers.

1.3 Justification

This study helps to have a clear picture on the best variety of tomato to smallholder farmers which will have better growth performance in terms of stem height, stem thickness, final yield and biomass to their soil type. This information will also assist smallholder farmers in Mash central who grow tomatoes, on the growth habits of both determinate and indeterminate varieties. When varietal selection is adopted and considered best before any production venture on tomato growing, it has positive contribution to the profitability of the crop. As a result, it is good to go through this research findings and get the necessary information that makes an expert on growing tomatoes.

1.4 Objectives

1.4.1 Main Objective

- To evaluate the performance of determinate (Rodade, Tengeru) and indeterminate (Star 9037, Candera) tomato cultivars on growth, yield and biomass parameters on open field management.

1.4.2 Specific Objectives

- To determine growth performance of determinate and indeterminate varieties on selected growth parameters (stem height, stem thickness) of tomatoes.
- To determine amount of biomass of determinate and indeterminate varieties on selected biomass parameter of tomatoes.
- To determine yield performance of determinate and indeterminate varieties on selected yield parameter (average weight per cultivar) of tomatoes.

1.5 Hypotheses

- There is no significant effect in the performance of determinate and indeterminate varieties on selected growth parameters (stem height, stem thickness and leaf length) of tomatoes.
- There is no significant effect on amount of biomass of both determinate and indeterminate varieties on selected biomass parameter of tomatoes.
- There is no significant effect on yield performance of determinate and indeterminate varieties on selected yield parameter (average weight per cultivar) of tomatoes.

CHAPTER 2: LITERATURE REVIEW

2.1 Origin and Distribution

The tomato has its origin in South America. Inspite of this, the tomato grows naturally. The first people to plant the plant tomatoes were the Mayans and the Aztecs. The earliest salsas were made by the Aztecs, who were the first to mix tomatoes with chili peppers. Alma, C.M (1963) it is still unknown how the tomato got to the Mayans and Aztecs in Central America, although it is likely that birds made sure it moved from South to Central America. Similar to chilies, tomatoes were dispersed by the Spaniards during their global expeditions. Thus, in the 16th century, the tomato was brought to Caribbean, Asia, and Europe.

The tomato was first described in Italy in 1544.Most tomato varieties were yellow when they were first brought to Europe, so the Italians called them 'pomo d'oro', which means golden apple (Gentilcore and David, 2010). To this day they call the tomato pomo d'oro. Gentilcore and David (2010), mentioned that tomato was not immediately appreciated by everyone in Europe. Even though the tomato was first introduced in the United Kingdom in the 16th century, it was not until the 18th century that the English began to appreciate this unusual (and possibly toxic) vegetable and began using it on a daily basis in their cooking. In their acceptance they were probably helped by the Southern European immigrants who entered the kingdom and who did appreciate the tomato. The distribution to the United States came later from both from Europe and from the Caribbean islands. Also, there the tomato is still as popular as ever. Tomatoes were then introduced in Zimbabwe by the European settlers in the late 19th century (Mashingaidze, 2005).

2.2 Taxonomy and Morphology

The genus Solanum, species S.lycopersicum referred to as Solanum lycopersicon, Linnaeus, (1753), belongs to the order solanales and family Solanaceae. One of the most diverse families of flowering plants, the family included between 1500 and 2000 species (Sato *et al*., 2012; Naika *et al*., 2005).

Bissonnette, (2017) states that tomatoes are herbaceous plants that can grow as determinate (bush-type) or indeterminate (vine-type) varieties. Determinate tomatoes require less support, while indeterminate tomatoes require more support and pruning (Hartmann *et al*., 2017) the determinate tomato variety produce the fruits at once whereas the indeterminate produce fruits continuously. The stem is green, hairy, and has a slightly ridged texture Tomato leaves are compound, oval shaped and have a pointed tip. The leaves consist of epidermis (outer layer),

mesophyll (photosynthetic tissue),and vascular tissue xylem and phloem (Evert, 2006).The plant structure consist of a taproot system, which have a main root that grows downward and smaller roots that branch out laterally. Tomatoes flowers are small, yellow, and arranged in clusters. They are perfect flowers having both male and female reproductive organs (Wehner, 2017). Because modern varieties have been developed to ripen uniformly red, the sweetness and flavour of the fruit have been compromised.

Several studies have also evaluated the performance of determinate and indeterminate tomato cultivars under open field. An example is the study by Johnson *et al.(*2018) found that determinate cultivar obtained higher yields compared to indeterminate tomatoes.However,other studies also contradict that indeterminate variety had higher yields and were disease resistant compared to determinate cultivars under rain-fed conditions(Williams, 2019).

2.3 **Nutrition Benefits of Tomatoes**

Tomatoes are mostly grown for food and as a cash crop globally. In various regions of the world, they are also used as decorative plants. Tomato is a significant vegetable crop that has grown in popularity during the past century. The plant is a multipurpose crop that falls into two categories, processing tomatoes and fresh market tomatoes.

Because of its flavor, color, taste,and nutritional value, tomatoes are now grown all over the world. Tomatoes may help maintain a healthy, well-balanced diet as it has a few calories and is a source vitamin A, vitamin C, and minerals. It offers trace levels of thiamine, riboflavin, and niacin, which are components of the vitamin B complex (Sainju and Dris, 2006). Iron is also found in tomatoes. Yellow tomatoes have higher vitamin A than red ones.

Red tomatoes contain lycopene, an antioxidant compound that may contribute to protect against cancer (Naika *et al*., 2005).The studies suggests that lycopene reduces the risk of prostate cancer (Miller *et al*., 2002).The risk of developing cardiovascular diseases and gastroenteric diseases such as colon, rectal can be reduced by eating tomatoes. Eating tomatoes can improve digestion, reduce bloating, and support weight management goals. The finest sources of lycopene are cooked tomatoes and tomato-based products because cooking releases lycopene. Twenty percent of cooked tomatoes' lycopene content was present in raw tomatoes. However, tomatoes are easily digestible, and its bright colour stimulates appetite (Sainju and Dris, 2006).

2.4 Factors affecting growth and yield of tomatoes

2.4.1 Genetic Factors

Genetic factors influence significantly influence the plant structures including the stem morphology of stem thickness and stem height on both determinate and indeterminate tomato varieties. Hence affecting the plant architecture on determinate or indeterminate growth patterns. Genetic makeup also influences the two plant structures on yield capacity and resource allocation. Some genetic traits can have resistance to some specific diseases and also impact on biomass accumulation (Kumar *et al*., 2016).

2.4.2 Environmental Factors

Environmental factors, such as temperature, light, water, and soil, significantly impact tomato plant growth and development on both determinate and indeterminate plants. Temperature, for example, affects tomato growth. Patel *et al*. (2020) found that tomato yields were mostly affected by high temperatures. Light intensity and quality also have an impact on photosynthesis influencing the energy production and also light exposure influence the plant morphology, fruiting and flowering. With inadequate light leading to weak and spindly plants (Singh *et al*., 2017).Moisture and soil type affects the root development and plant growth for tomato crop.

2.4.3 Agronomic Practices

Practices like irrigation, fertilization, pruning, and pest and diseases management, play a vital role in determining tomato yields. Irrigation scheduling, for instance, affects tomato growth, with over-irrigation leading to reduced yields and increased disease susceptibility (Kumar *et al*., 2016). Fertilization also impacts tomato growth; poor fertilizer application can influence the plant growth especially on stem thickness and stem height and also fruiting. Pruning and training also influence the plant structure and yield determination.

2.4.4 Nutritional Factors

According to Singh *et al*., (2017), nutritional factors such as nutrient deficiencies, can significantly impact tomato growth and yields. Nutrient deficiencies, such as nitrogen, phosphorus, potassium, and micronutrient deficiencies, can lead to reduced growth rates on stem height, leaf length and stem thickness, lower yields, and increased disease susceptibility.

2.5 Description of tomato varieties used

2.5.1 Tengeru

It is a popular tomato variety in east Africa, also known for producing high yields and disease resistance to fusarium wilt and verticillium wilt (Kumar *et al*., 2016). Tengeru is a determinate variety, producing round medium sized fruits with also a bright red color and a sweet, acidic taste. This variety matures in 70 to 80 days. It also suitable for fresh market, processing, and canning. Tengeru has a compact, bushy growth habit with simple, dark green leaves. They are bred to grow to a compact height of about 1.2m.They ripen their entire crop at or close to the same time, which is typically around a month, and then die when fruit develops on the terminal or top bud. They could need some staking and caging for support, should not be pruned or "de-suckered" as it drastically lowers the crop (Smith, 1994; Jones, 2012).According to the past study, Tengeru thrive in open fields either trellised or not, they have proven productivity the whole year in Zimbabwe.

2.5.2 Rodade

According to Patel *et al*., (2018) Rodade is a determinate variety known for producing high yields and resistance to diseases such as bacterial wilt has a semi-compact growth habit and also a medium to long shelf life. Their fruits are medium sized, with a bright red colour and a sweet, slightly acidic taste. The Rodade matures in 75 to 85 days. They perform well on open field including full sun in spring and summer.

2.5.3 Candela

They are indeterminate tomato variety, characterised by its high yields and long shelf life (Singh *et al*., 2017). Its fruits are elongated, with bright red colour, oval shaped and sweet, slightly acidic taste and they take 75 to 90 days to mature. They are suitable for fresh market and canning. Candela has a high vigour, very compact plant with good disease package. Their performance on open field is reliable and productive in Zimbabwe giving high yields giving 90-130 tonnes per hectare.

2.5.4 Star 9037

It is a hybrid tomato variety, characterised by its high yields and resistance to diseases such as powdery mildew and Septoria leaf spot (Kumar *et al*., 2019). Its fruits are round large, with a bright red colour and a sweet, slightly acidic taste. Maturity days are 90 to 95 days after

transplanting in summer. The hybrid has the potential to produce an extra set or flush of fruit before reaching the top end of the trellising structure. Another name for indeterminate varieties is “vining” tomatoes. They can grow to a height of 3-6m and bear fruit for a long time, sometimes more than a year. The varieties bloom, set new fruit and ripen fruit all at the same time throughout the growing season. For support, pruning, and removal of suckers, they need to be heavily staked and or caged.

CHAPTER 3: MATERIALS AND METHODS

3.1.1 Site Description

The study was conducted at Nyakudya farm from Mazowe District which is in Mashonaland central province from 22 January to 31 May 2025.The area is located 6.km peg away from Nzvimbo Growth Point Centre. The farm is in region 2b of Zimbabwe. The climate is sub-tropical highland climate with dry winters. The annual rainfall in this area ranges from 700-1000mm per year. Temperatures ranges from 20-25 degrees Celsius in winter. The soils are sandy loam soils with good drainage with latitudes of S 17º19’15, E 31º 02’30.

3.2 Experimental design

Four certified tomatoes varieties namely determinate (Rodade, Tengeru) and indeterminate (Star 9037, Candela) was used in the experiment. Treatments were arranged in a Randomized Complete Block Design (RCBD) with 4 treatments and replicated 3 times, therefore there were 12plots altogether. There were 3 blocks with 1metre pathway between the beds. Each plot measured 3m by 3m. The blocking factor was slope.

Table 3 1: Experimental layout plot

B1	Plot 1 **V1**	Plot 2 **V4**	Plot 3 **V2**	Plot 4 **V3**
B2	Plot 5 **V2**	Plot 6 **V1**	Plot 7 **V3**	Plot 8 **V4**
B3	Plot9 **V4**	Plot 10 **V3**	Plot 11 **V1**	Plot 12 **V2**

KEY

V1: Rodade plus **V3: Tengeru plus**

V2: Candela **V4: Star9037**

3.3 AGRONOMIC PRACTICES

3.3.1 Land Preparation

The land was disced using a rom disc drown by 75 horsepower tractor, and the beds were constructed containing 3 blocks with 1metre pathway between the beds. Each plot was 3m by 3m.

3.3.2 Planting

It was done using same number of seedlings per variety (Rodade, Tengeru, Star 9037 and Candera), per plot with an in-row spacing of 40cm interrow spacing 70cm.

3.3.3 Fertilizer Application

It was done manually using human labour through drilling and top-dressing method. A week after planting, Compound D fertilizer NPK (7:14:7) with 250kg per hectare was applied through drilling as a basal fertilizer. Then Ammonium nitrate fertilizer was also applied as top-dressing thrice at fortnight interval soon after planting using an application rate of 5g per plant. Foliar Application using quick based was applied to boost crop growth at flowering stage and vegetative growth.

3.3.4 De-Suckering

Removal of sideshoots on indeterminate types to maintain 1 main stem without side branches was done at regular intervals.

3.3.5 Trellising

Support was necessary and was done for those varieties with vine which cannot top like indeterminate (Star 9037) variety and these need support so trellising the tomato on poles and wires for them to grow upright was done.

3.3.6 Weed Management

Was required to prevent nutrient competition such that the field was kept clean at all times and in this case, it was done manually by hand weeding and hoeing.

3.3.7 Pest Management

Pesticides were also applied such as fungicides and insecticides and using knapsacks15L. Carbaryl and nemesis are the insecticides which are going to be applied for controlling the

insects like Tutor absoluter. Carbaryl to be applied soon after planting for controlling cutworms and other insects that would infect transplanted seedlings and then nemesis to be also applied whenever there was too much pest infestation discovered. Copper oxychloride, mancozeb are the fungicides which were applied for controlling diseases. Mancozeb and copper oxychloride are applied at weekly basis soon after transplanting.

3.3.8 Harvesting

It was done manually per individual plot, variety, and plant.

3.4 DATA COLLECTION

- Stem height
- Stem thickness
- biomass
- Yield

3.4.1 Growth

- Data on stem height and thickness was collected fortnightly.
- Stem height measurement using a 30cm ruler was placed from the soil surface to the topmost growth points of above ground plant part. The measurement was taken as the length from 5 plants of each plot.
- Stem thickness was measured as the circumference of the stem using a string at 10cm stem height above the ground.
- Data was collected on 20 samples of plants and 5 plants per variety and per plot from each block.
- Data on growth parameters are going to be measured using a 30cm ruler and readings were recorded in cm.
- Data was collected 5 times starting from transplanting day.

3.4.2 Yield

- Fruit fresh weight during harvesting was measured using a scale and the readings in grams.
- Fruits randomly selected from 5 plants per variety from each block at full fruit maturity stage were weighed.

3.4.3 Biomass

- Plants that were sampled and selected at random from different plots and cleaned to remove all dirt, then subjected to the process of desiccation in a solar oven to eliminate moisture present.
- They were put in the oven for 3 days and then removed. After dehydration, mass of the plants was quantified and recorded.

3.5 DATA ANALYSIS

The data on growth rate (stem height, stem thickness), yield and biomass were subjected to analysis to variance using (ANOVA) in GenStat statistical package. The least significant difference was used for mean separation.

CHAPTER 4: RESULTS

4.1 Performance of tomato varieties on Stem Height

Table 4.1**:** *performance of tomato varieties on stem height*

Variety	Mean Height (cm)
Candela	35.12[a]
Star 9037	34.60[a]
Tengeru	34.14[a]
Rodade	28.32[b]
P-value	0.010
SED	2.299
LSD (5%)	4.524

They were significant differences among the different varieties in terms of plant height ($p<0.05$). While Candela had the tallest plants (35.12 cm), it was statistically similar to Tengeru, and Star 9037. Rodade was significantly shorter than the other varieties. This has been illustrated on the table 4.1 above.

4.2 Performance of tomato varieties on Stem Thickness

***Table 4.2**: performance on stem thickness*

Variety	Predicted Thickness
Candela	1.176[a]
Tengeru	1.134[a]
Star 9037	1.104[a]
Rodade	1.091[a]
P-value	0.761 (ns)
SED	0.085
LSD (5%)	0.168 (ns)

The different tomato varieties had no significant differences among them (p=0.761). While they were actual differences in measured dimensions, there was no statistical difference among different varieties (Table 4.1).

4.3 Performance of tomato varieties on Biomass

***Table 4.3**: performance on biomass*

Variety	Biomass (g)
Candela	30.25[b]
Rodade	46.83[a]
Star 9037	34.00[b]
Tengeru	41.83[a]

P-value	<0.001
SED	1.116
LSD (5%)	2.253
Grand Mean	38.23
CV (%)	7.2
Standard Error	2.734

Analysis of variance revealed significant differences ($p<0.001$) in biomass production. Rodade and Tengeru were statistically similar and significantly higher in biomass accumulation compared to Candela and Star9037 suggesting superior vegetative growth in these two varieties (Table 4.3).

4.4 Performance of tomato varieties on Yield

Figure1: *Performance of tomato varieties on yield*

Analysis of variance did not reveal any statistical differences among the varieties (p=0.162). While Rodade and Tengeru had higher yields numerically, they were in the same statistical grouping as Candela which had the lowest total (figure 4.1).

CHAPTER 5: Discussion

5.1 Stem Height

Analysis of plant height showed significant differences ($p<0.05$) between the indeterminate varieties Candela and Star 9037 and the determinant varieties Rodade and Tengeru. This may be seen as a reflection of growth habits. Indeterminate tomatoes continue vegetative growth over extended periods of time being capable of reaching or exceeding 2m under ideal conditions. (Hartman *et al*. 2017). Determinate cultivars on the other hand exhibited significantly reduced plant height which is in line with its compact bush type growth form (Smith, 1994). This differentiation is mostly genetic as determinate tomatoes are bred to allocate more resources towards synchronized fruiting as opposed to prolonged vegetative development (Kumar *et al*. 2016). Furthermore, Singh *et al*. (2017) noted that plant height is heavily responsive to nutrient availability more so nitrogen and potassium. Taking into consideration that all varieties were exposed to uniform fertilization, the observed differences can be attributed to inherent genetic architecture. These results strengthen the importance of growth habit in varietal selection more so when canopy size and support systems are considerations for open fields tomato farming.

5.2 Stem Thickness

The insignificant differences in stem thickness amongst the different varieties suggest that this trait may be less influenced by growth habit and more depending on uniform environmental conditions and management practices. Even though indeterminate varieties such as candela and start 9037 showed slightly thicker stems numerically, their advantage was not statistically significant. This is consistent with outcomes noticed by Kumar *et al*. (2016) who indicated that stem morphology can be genetically constrained and not always indicative of performance differences. According to Hartman *et al*. (2017). The stem thickness does not necessarily vary drastically between growth habits more so under optimal agronomical conditions. Likewise, Singh *et al*. (2017) observed that nutritional factors such as a balanced fertilization minimized inter varietal differences in stem thickness. Because all stem varieties were subjected to similar agronomic and environmental conditions, the similarity in stem thickness shows how management practices and genetic factors interact to limit phenotypic divergence in this characteristic.

5.3 Biomass

Analysis of plant biomass produced highly significant variations for the different varieties ($p < 0.05$) highlighting the differential ability of genotypes to allocate resources to vegetative structures. Tengeru and Rodade both, determinate varieties produced more biomass than Star 9037 and Candela likely as a result of the genetic tendency to accumulate bulk in the earlier part of the season before fruit setting (Kumar *et al*. 2016). According to Johnson *et al*. (2018) higher early season vegetative vigor in determinate cultivars is a defining characteristic under open field conditions. According to a study undertaken by Bissonnet (2017) indeterminate varieties such as Candela and Star 9037 oftentimes concentrate more assimilates towards prolonged fruiting as opposed to vegetative mass accumulation. Explaining their relatively lower biomass. Environmental conditions also exert influence. Singh *et al*. (2017) emphasize that sufficient light intensity and soil moisture enable robust vegetative development. Taking into account that management practices were similar the biomass difference observed indicates that genetic and morphological growth patterns strongly influence dry matter partitioning with determinate varieties favouring a more concentrated vegetative accumulation stage.

5.4 Yield

In spite of the numerical differences, yield variations noted among the different varieties were not statistically significant indicating that all 4 varieties performed comparably under the given conditions. This result is consistent with outcomes noted by Williams (2019) who observed that indeterminate varieties may not always outperformed determinate ones in yield under open field rain-fed systems. The fact that Rodade and Tengeru were statistically similar to Candela and Star 9037 suggests that determinate types can be as productive as their indeterminate counterparts when environmental and agronomic variables are optimized. Notably Johnson *et al*. (2018) noted that determinate cultivars are able to compete with indeterminate varieties yield wise through efficient early season fruiting. A study undertaken by Kumar *et al*. (2016) emphasized the role of genetic resistance to diseases in supporting maintained yield potential which may benefited Rodade and Tengeru. It can therefore be said that yield is a complex trait influenced by the interaction of genotype, environment, and management as opposed to plant habit alone.

CHAPTER 6

6.1 Conclusion

The results indicated that there is significant difference in stem height, indeterminate varieties (Candela and Star 9037) are taller than determinate ones. Rodade were significantly shorter, reflecting its compact determinate architecture. On stem thickness, there was no significant difference among all varieties indicating that it was not influenced by the growth habits. In terms of biomass, the results revealed that there was significantly difference, both determinates producing more biomass than indeterminate varieties. The results show a better capacity of vegetative growth and resource use efficiency under open-field management. However, yield did not reveal significant differences, although Rodade and Tengeru reveals higher numerical yields compare to Candela.

6.2 Recommendation

1.According to the results generated by the research, there are several suggestions that can be made.Firstly,l recommend farmers to choose varieties based on production cycle i.e. for longer periods and staggered harvesting, indeterminate varieties(candela)still valuable especially where market timing and supply continues is a goal ,though they have lower biomass performance.

2. Farmers should grow Rodade and Tengeru due to their higher numerical yields showing that determinate varieties may perform slightly well under open field conditions with uniform management, although yield differences were not significant.

3. For farmers assessing vegetative biomass where leaf coverage is beneficial in weed suppression and control of erosion, Tengeru and Rodade are recommended, as they revealed higher biomass accumulation.

4. Farmers should focus on other selection traits like biomass or stem height rather than stem thickeness.this is because consistent values across all cultivars suggest that stem thickness is not a limiting factor under the current management system.

5. However, there is also needed for carrying out further research in future on evaluating the performance of different tomato varieties using same approach on growth, biomass, and yield parameters. This enables farmers to come up with the best and most productive varieties so as to achieve diversity and increase productivity. There is need for research on indeterminate varieties, the whole cycle for accurate read on yield and cost

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APPENDICIES

1-Appendix 1:analysis of variance on stem height

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Block stratum	2	22.8	11.4	0.06	
Block.*Units* stratum					
Variety	3	2268.4	756.1	3.82	0.01
Residual	294	58262.3	198.2		
Total	299	60553.5			

2.Appendix 2. analysis of variance on stem thickness

Source	d.f.	s.s.	m.s.	v.r.	F pr.
block	2	0.3825	0.1912	0.9	0.41
variety	3	0.2491	0.083	0.39	0.761
Residual	239	51.0549	0.2136		
Total	244	51.6864	0.2118		

3.Appendix3.analysis of variance on biomass

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Block stratum	2	27.562	13.781	1.84	
Block.*Units* stratum					
Variety	3	2022.896	674.299	90.19	<.001
Residual	42	314.021	7.477		
Total	47	2364.479			

4.Appendix 4. analysis of variance on yield

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Block stratum	2	28.572	14.286	1.76	
Block.*Units* stratum					
Variety	3	59.487	19.829	2.44	0.162
Residual	6	48.668	8.111		
Total	11	136.727			