Evaluation of Tomato (*Solanum Esculentum L.*) Cultivars for Growth Rate, Yield and Yield Components, and Nutritional Value Grown Under Open Field Conditions in the Lowlands of Mohale's Hoek, Lesotho

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Abstract: Tomato (*Lycopersicon esculentum* L.) has been produced for a century by households in the backyard gardens to meet home consumption. Nonetheless, demand for it has escalated necessitating importation from South Africa. This importation encouraged progressive vegetable farmers to grow it without much research undertaken on their growth rate, nutritional value and yield potential. The objectives of study were three manifolds; (i) to determine growth rates of eight tomato cultivars grown under open field conditions, (ii) to evaluate tomato cultivars for nutritional quality using laboratory techniques, (iii) to identify high yielding cultivars of tomato. Study was conducted in the Mohale's Hoek district located 117 km south of Maseru, capital town of Lesotho. Randomized Completely Block Design was applied in laying out an experiment consisting of eight treatments (tomato cultivars) and three replications. Dimensions of main-plot were 20m x 12 m, while sub-plots measured 1.8m x 2m. Number of rows per plot was three, while inter-row and intra-row spacing were 60cm x 60cm, respectively. Growth parameters were measured for five intervals of three weeks, thus; 3, 6, 9, 12 and 15 weeks. Growth parameters were plant height, stem diameter, stem height and leaf area index. Yield parameters were measured at three intervals; early, middle and late harvest. Parameters were: days to 50% flowering, flowers per cluster, days to fruiting, plant population stand, fruit weight, fruit length, fruit diameter and marketable percentage. Nutritional parameters measured were: titratable acidity, sugar acid ratio, total soluble solids, ash content and moisture content. Data generated on growth rate, nutritional value and yield were analysed using analysis of variance to determine significant differences. Cultivars with the highest growth rate were Cherry Little Wonder, Money Maker and Hot Stuff. They commenced growth from week 3 to week 9 at an exponential rate, after which growth occurred at a logarithmic rate until week 15. Beyond week 15, they grew at an arithmetic rate to harvesting time. Tomato yield was highly influenced by plant population stand, number of fruits in a plant, fruit weight, fruit diameter, and marketable percentage per cultivar. Regarding nutritional value for different cultivars, Cherry Little Wonder, Money Maker, Rodade, Heinz and ash content had the highest titrable acids, sugar acid ratio, total soluble solids, lycopene and ash content, respectively. It can be concluded that Cherry Little Wonder, Rodade and STAR 9065 were ranking high in most of the parameters studied. It is recommended that they be evaluated under different environmental conditions.

Keywords: *Growth Parameters, Nutrition Parameters, Tomato Cultivars, Yield Parameters.*

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I. INTRODUCTION

The cultivated tomato species *Solanum lycopersicum* (formerly Lycopersicon esculentum) [1] is the worlds' most highly consumed fruit. It belongs to a family of *Solanaceae* with other several commercially important genera which include green pepper (Capsicum *annum* L.), Irish potato (*Solanum Tubersum* L.), eggplant (*Solanum melongena* L) and tobacco (*Nicotiana tabacum*) [2; 3]. Tomato originates from wild plant in Southern America, thus; Peru, Bolivia, Chile, Colombia, and Ecuador. The centre of its domestication and diversification is Mexico [4]. It was introduced in to

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Europe in the 18th century and then spread to Africa and Asia. Some countries within these two continents began to grow adaptable cultivars and developed new more high yielding and quality types [5]. Tomato evolved over time to produce more than 7500 cultivars through natural means and artificial hybridization.

Tomato is now grown world-wide and has become an important commodity in international trade such as European Market. In 2021, the world production of tomatoes was 182 million metric tonnes (m/tonnes) and the leading producers were China, India, United States of America, Turkey, Egypt, Iran, Italy, Spain, and Brazil with 56.4 m/tonnes, 18.4 m/tonnes, 13 m/tonnes, 12.6 m/tonnes, 7.9 m/tonnes, 6.3 m/tonnes, 6.3m/tonnes, 4.6 m/tonnes and 4.1m/tonnes, respectively [6]. In Africa, Egypt had the highest production of 6.25 m/tonnes constituting 29.21% of total continental production of 21.4 million tonnes. It is followed by Nigeria, Algeria, Tunisia and Morocco with 6.2 m/tonnes, 3.5 m/tonnes, 1.6 m/tonnes, 1.4 m/tonnes, and 1.3 m/tonnes, respectively. Tomato production from four African countries accounted for 66.36% of 43 countries that broke the records [6]. In sub-Saharan Africa (SSA), tomato fruit is an important cash crop [7]. Production systems adopted differ greatly throughout the continent depending on the agro-ecological zones, from greenhouses to open field, with varying levels of technological applications. In Africa, tomato is one of the most widely grown fruit vegetable due to its versatility in production cutting across smallholder and commercial farming communities.

In Lesotho, tomato is the most cultivated horticultural crop (78%) under protected structures [8]. The production of tomato in Lesotho is 3,584 tonnes per ha, while its consumption is 31,000 tonnes. It is mainly grown for both home consumption and domestic market. The crop is grown under both rain fed and irrigated conditions in greenhouses to prolong season production since the crop is bound by seasonality. It is specifically affected by low winter temperature which occurs in the months of May, June and July. Notwithstanding, the area under production has been increasing yearly because of increased demand for the crop.

Globally, tomato is used as a mature fruit either raw or processed. Products processed from tomatoes are chutney, paste, sauce, puree, juice, fresh salad vegetable, and stewed, fried, baked and canned tomato. Nutritionally, tomato has 95% water, with a fruit weighing an average of 100grams constituting 8 calories, 0.9 grams protein, 3.9grams sugar, 1.2grams fibre, 0,2 grams fat and minerals, especially phosphorus and iron [9]. Moreover, it is also high in vitamin C, K, B9, carotene, phenolic acids and flavonoids [10]. Besides, it has medicinal properties such as anti-inflammation, immunity system booster, cholesterol reduction, prevention of blood from clotting [11]. Ripe tomatoes have a high content of the anti-oxidant lycopene, which plays a possible role in the prevention of certain forms of cancer and is vital in controlling chronic diseases [12].

Within the tomato genera, there are many cultivars differing greatly in economic traits such as growth rate, nutritive value and yield which are determined by both genetic constitution and environmental factors. Among the cultivars, there are short maturing taking 60 days, medium lasting for 90 days and others are late maturing growing up to 140 days. Indeterminate cultivars can grow all year round as long as they are provided favourable conditions.

Tomato is one of the most popular fruit crops produced in Lesotho and is sold in the domestic market both in fresh and in processed form. It is produced at a small scale mostly for home consumption and the surplus is sold in the neighbourhood. Recently, there are emerging farmers who produce under protected structures at a larger scale for sale to generate income, though the supply is not constant because of low level of production. Through Government and Donor Agents' support for protected structures, many people including farmers have ventured into tomato production which seems to give a lucrative profit. Nonetheless, the farmers lack technical information on the cultivars suitable for the different localities, their growth rates, nutritive values and yield potential, which cannot be emphasized in the production, marketing and consumption of tomato. Most of the farmers who embarked on tomato production failed because of not acquiring this valuable knowledge. The institutions mandated to generate the knowledge are inadequately capacitated with the resources to execute their research diligently and disseminate it to the end-users. Hence, the tomato production industry is not progressive and flourishing.

Upon completion of the study, the farmers and agricultural professional will acquire valuable knowledge related to cultivar differentials on growth rates, nutritive value and yield potential. They will make an informed decision and choices for their localities, desired yield level, and consumer preferences. Generally, the characteristics of all the commonly grown tomato cultivars will be known to the farmers. The findings from the research if well adopted will increase tomato production, which will in turn increase income for the family and improve the standard of living in the households. Importation of tomato into the country will be reduced.

Specific objectives of this study were three manifolds: (i) to determine growth rates of eight tomato cultivars grown under open field conditions, (ii) evaluate the tomato cultivars for nutritional quality using laboratory techniques, (iii) identify the high yielding cultivars of tomato.

II. MATERIALS AND METHODS

➢ *The Study Area*

The experiment was conducted in the Mohale's Hoek District domiciled 99.3 km south of Maseru, which is the capital town of Lesotho. The specific site in the Mohale's Hoek District was at the Institute of Extra Mural Studies campus of the National University of Lesotho. This site is located in the agro-ecological zone of lowland area where an altitude is 1,598 m above sea level and longitude 30.1426^0 S, and 27.4674^0 E.

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➢ *Site Description*

Soil type in the site is originated from basaltic rock and has a deep profile with rich organic matter. The soil color is predominantly black which indicates high organic matter content. It is a very hot and dry in summer and prone to drought which makes cultivation of summer crops very difficult. On the average, annual temperature is 160 C, while highest temperature is 350 C occurring in summer and lowest is -40 in winter [6]. The average annual rainfall is 769 mm and has 104 rainy days, which is approximately 29% of 365 days of the year [6]. The rain commences in October and increase gradually until January to February, after which it decreases sharply until April. May, June, July and August are dry months of the year. In winter season, snowfall is experienced [1]. Frost occurrence is erratic, but generally starting end of April. Number of frost-free days is approximately 150-170 and an annual average wind direction and speed is South western and 1.88 km/h.

➢ *Experimental Design*

The experiment was conducted at an open field using Randomized Complete Block Design with eight (8) treatments (cultivars) and three (3) replications. The treatments consisted of five determinate cultivars, namely; Roma, Rodade, Heinz, Star 9065 and 9009, and three indeterminate cultivars; Cherry Little Wonder, Money Maker and Hot Stuff (Table 1). The dimensions for the main plot were 20 m by 13m and size of each sub-plot was 2 m by 1.8 m having 12 plants. Each plot had 3 rows with 4 plants on each. The intra and inter row spacing were 60 cm by 90cm, respectively.

Table 1 List of Tomato Cultivars, Growth Habit and Breeding Company

Cultivars	**Growth habit**	**Company**
Roma	Determinate	Starke Ayres
Rodade	Determinate	Starke Ayres
Heinz	Determinate	MayFort
Star 9065	Determinate	Starke Ayres
Star 9009	Determinate	Starke Ayres
Cherry Little Wonder	Indeterminate	Starke Ayres
Money Maker	Indeterminate	Starke Ayres
Hot Stuff	Indeterminate	Starke Ayres

➢ *Agronomic Practices*

Soil testing was performed before transplanting to determine the fertility status of the soil and acidity at the experiment site. This was useful in determining the amount and type of fertilizer required for the experiment. Five random soil samples were taken from different locations of the field, stones removed by hand, and samples ground into finer particles. Samples were mixed together thoroughly to make one composite sample, after which 300g was taken for soil analysis to the Soil Science laboratory at the Department of Agricultural Research, Maseru.

➢ *Seedling Production*

Seeds were sown in seedling trays at depth of about 0.5 cm and covered with plastic cover to increase the temperature in soil and to keep the soil moist while the seeds are germinating. The trays were kept under shading-net for eight weeks. The seeds germinated from day 10 to day 16 after sowing. On the 11th November, healthy seedlings were selected and transplanted into the prepared plots. Few days later, it started raining and the soil was kept moist by mulching using dry grass.

➢ *Seedbed Preparation*

The land was prepared and dug using a spade, after which it was raked to break the large clots, level the seedbed and make fine tilth suitable for the growth of tomato crop. Decomposed organic matter was incorporated into the soil. Lines were drawn to make rows and within the rows intra-row spacing were marked. Transplanting of tomato seedlings was carried out following afore-mentioned spacing. Rings were made around each transplanted seedling where a compound fertilizer of 3:2:4 (24) (N:P:K) with 22% organic matter was applied. Weeding was performed five (5) times to control a high level of weed infestation caused by heavy rainfall which occurred throughout the season.

➢ *Tomato Crop Management*

Staking was done approximately one month after transplanting to support them off the ground, while assisting their upward growth habits and to keep off plants from ground contact which may otherwise contract soil borne diseases from the ground. Mulching was applied using dried grass and leaves to reduce evaporation losses and also to prevent weed seed germination. The vines were supported by stakes up to 1.0 m length placed at the side of each plant. The fungicides and insecticides were applied once after the harvest was undertaken to control late blight (Phytophthora infestans) and early blight (Alternaria solani) The spray regime followed the label recommendations.

➢ *General Manangement and Observations*

Flower initiation started at about 33 - 37 days after transplanting and became continuous. Nothing was being applied at this stage. Fruit setting commenced 45 - 47 days after germination. The first harvest started after 80-90 days after transplanting.

III. DATA COLLECTION

Three plants per plot were randomly selected and tagged for data collection. All the data were collected from these tagged plants.

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Growth parameters measured were plant height, stem diameter, main lateral branch length, leaf area index and they were measured on each cultivar. Plant height (cm) was measured from the ground surface to the tip of plant using steel ruler. The average was calculated for each cultivar. The stem diameter (mm) was measured using the vernier calliper, the main stem length (cm) was measured using steel ruler. Leaf area index (cm^2) was calculated using the formula, X=0.5 ×L × W according to Bhattarai *et al*., (2018) [13].

Yield and yield components measured were: the plant population density (PPD), number of fruits per plant (NFPP), fruit weight (FW), fruit length (FL), fruit diameter (FD), marketable and unmarketable fruits yield and total yield at harvest.

- *Nutritional quality was determination of total soluble solids (TSS)*

Well ripened tomato fruits were selected and cleaned using distilled water, after which it was sliced then blended using an electric blender. Juice drops were deposited onto the prism of the refractometer. The soluble solid were determined as % Brix form the extracted juice and the activity was repeated three times to get the accurate results for each treatment (A TAGO N-IE, Japan), ranges start from 0-85%.

- *Determination of pH and Titratable Acidity (TA)*

Tomato fruits were homogenised with an electric blender for 1minute. The fruit puree was then filtered. 10 ml of filtered tomato juice was added to 50ml of distilled water and titrated with 0.1 M NaOH using 3 drops of methyl red indicator solution. Total titratable acidity as citric acid was calculated as per Singh *et al*. (2014) [25].

- *Determination of Lycopene Content*

100g sample was ground to a homogeneous puree using an electric tissue blender and transferred into 250ml beaker. Subsequently 50ml hevane-acetone-ethanol mixture (2:1:1) was added into the beaker and shaken for 15minutes on an electric shaker. Thereafter, 3 ml of distilled water was added and the sample was shaken for 5 minutes. The solution was transferred into 250ml separately funnel and allowed to stand for 5minutes to enable phase separation, thereafter upper layer (hexane) was then collected using pipette into an amber screw capped vial. An aliquot of the hexane extract was then transferred into a 1ml quartz cuvette and the absorbance taken at 503 nm against the solvent-blank using UV Visible spectrophotometer. The lycopene content of each sample was then estimated using the Dunsin *et al*., (2016) [14] method.

- *Determining of Ash Content*

A crucible was dried for 2 hours at 100 °C in the oven, after which it was transferred into a desiccator to cool down and its weight was recorded (W1). 5g of sample was weighed into the crucible (W2). The samples were burnt in a furnace at 600 °C for 2 hours. Crucible was removed from furnace and allowed to cool in a desiccator and weight (W3) [15].

% Ash (dry basis) =

Where = weight of empty crucible

- *Determining Moisture Content*

10g of chopped tomato was put into a pre-weight petri-dish dried in an oven at 105°C for four hours and then allowed to cool. The petri dish was then weighed [16].

- *Statistical Analyses*

Data generated from growth rate, yield and nutritional value was subjected to analysis of variance (ANOVA). Mean comparison tests were carried out using Least Significant Difference (LSD) at P= (0.05) *, (0.01) ** and P= (0.001) *** to separate treatment means.

IV. RESUTLS AND DISCUSSION

- *Determination of Growth Rate Among Different Cultivars of Tomato*

- *Differences Among Tomato Cultivars for Plant Height, Main Stem Height, Stem Diameter and Leaf Area Index.*

There was a highly significant difference among the cultivars for plant height and main stem height (P>0.01; Table 2). Three cultivars with tallest plant height were Money Maker (82.33cm), followed by Cherry Little Wonder (81.67cm) and, lastly Hot Stuff (69.17cm) (Table 3). The cultivars with shortest plant height were Rodade (49.33cm), followed by Heinz (51.33cm) and then Roma (54.00cm). Cultivars with the tallest main stem height were Cherry Little Wonder (18.00 cm), followed by Money Maker (17.33cm) and Star 9009 (16.83cm) (Table 3). Cultivars with shortest stem height were Star 9065 (16.17cm), followed by Heinz (16.33cm) and Roma (16.33cm).

Differences in plant and stem height were attributed to genetic variability among tomato cultivars. The results showed explicitly that there were genes conferring tallness, others conferred shortness and some conferred intermediate height. The genes determined the heights and no environmental conditions influenced the difference since all the eight cultivars were grown on the same environment given similar treatment. Plant height and main stem height gradually increased with age of plant, even though in the later stage both stem and plant heights increased at a decreasing rate. This was due to the fact that the rate of cell division and multiplication at an early stage of growth was rapid and slowed down as the plant approached physiological maturity, after which senescence stage ushered and terminated both cell division and multiplication [17]. These findings were consistent with the results of Islam, et al. (2017) [18], who conducted research on 14 tomato cultivars and found that there were variations in plant height and stem height, though some cultivars were having similar stems and plant heights. Murakami et al. (1997) [9] explained that cultivars which shared similar heights also shared similar genes. Tallness and shortness were cultivar characteristics controlled and expressed by genes, though environment also had a perceptible influence [10; 14]. Furthermore, Olaniyi et al., (2010) [19] postulated that cultivars sharing the character such as height originate from the same progenitors. Two distinct sets of genes were observed in the growth patterns of indeterminate and determinate cultivars [14]. In this study, plant height results followed a similar pattern with those of

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Ali (2020) [20] and Tigist et al (2019) [21] who reported tallest height of 91 cm and 113cm, while the shortest was 62cm and 21.9cm, respectively.

- *Stem Diameter*

There was a significant difference among cultivars for stem diameter (P>0.05) as depicted in Table 2. Cultivars with the biggest stem diameters were Roma (1.33mm), followed by Star 9065 (1.3mm) and lastly Heinz (1.27mm). Table 3 showed the difference). Cultivars with smallest stem diameters were Cherry Little Wonder (1.0mm), followed by Money Maker (1.03mm) and lastly Hot Stuff (1.1mm).

Tomato stem diameter seemed to vary greatly among cultivars based on growth habit. Roma and Star 9065 which were determinate shared the same size of stem diameter, while Cherry Little Wonder, Money Maker and Hot Stuff which were indeterminate revealed smaller diameter.

These results were similar to those reported by Nath et al (2017) [11] who obtained the biggest stem diameter of 1.21mm and the smallest diameter of 0.9mm. He further indicated that between the two afore-mentioned diameters were from intermediate cultivars still varying, making a range from small to biggest. He attributed the variation in diameter being the variability of genes constituting each cultivar.

- *Leaf Area Index*

There was a highly significant difference among the cultivars for leaf area index (P>0.05). Table 2 revealed the differences. Cultivars with highest leaf area index were Cherry Little Wonder (4.23cm2), Hot Stuff (4.20cm2) and Money Maker (4.00cm2). The cultivars with lowest leaf area index were Star 9065 (3.6cm2), Heinz (3.71cm2) and Rodade (3.70cm2). Table revealed the differences). Thus, leaf area index in tomato at 15th week ranged between 3.6 – 4.23cm2.

The leaf area index was constituted by length and width of the leaves multiplied by mung bean leaf factor to obtain leaf area index. Leaf area indices were varying widely among the cultivars. Cherry Little Wonder (4.23cm2) and Hot Stuff (4.20cm2) were close to each other with a very thin margin of leaf area indices between them. Of course, the two had the largest leaf area index. Similarly, Heinz (3.71cm2) and Rodade (3.70cm2) experienced a very thin margin of leaf area index between themselves. The difference between two afore-mentioned group revealed that both members of a group shared almost similar gene constitution. Hussain et al (2017) [7] and Bhattarai et al (2018) [13] reiterated that where the environment was uniform in all aspects and there was difference in leaf area index that should be attributed to genetic constitution. Furthermore, he indicated that where there was a high degree of similarity among cultivars, it meant they shared the same genes for that particular trait in question [23].

Table 2 Summary of Analysis of Variance for Growth Parameters, Plant Height, Main Stem Height, Stem Diameter and Leaf Area Index

Source of variation	Df	Mean square			
		Plant height	Main stem height	Stem diameter	Leaf area index
Cultivars	7	540.618***	1.975**	0.048***	0.244***
Error	16	10. 729	0.676	0.007	0.062
Total	23				

*** Highly significant at p <.001; ** significant at P<.01; * significant at p <.05;

df = Degree of freedom

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Table 3. Means for Growth Parameters, Plant Height, Main Stem Height, Stem Diameter and Leaf Area Index of Tomato Cultivars at 15th Week After Transplantation

Cultivars	Characteristics			
	Plant height (cm)	Main stem height (cm)	Stem diameter (mm)	Leaf area index (cm^2)
Cherry Little Wonder	81.67	18.00	1.00	4.23
Money Maker	82.33	17.33	1.03	4.00
Hot Stuff	69.17	15.50	1.10	4.20
Star 9009	63.83	16.83	1.23	4.13
Roma	54.00	16.50	1.33	3.53
Heinz	51.33	16.33	1.27	3.70
Rodade	49.33	15.83	1.23	3.71
Star 9065	53.17	16.17	1.30	3.60
Grant mean	63.10	16.56	1.19	3.90
Standard deviation	12.31	1.04	0.14	0.34
Standard Error	2.51	0.21	0.03	0.07
Coefficient of variation (%)	20.16	4.61	11.77	8.72
P value	0.000	0.036	0.001	0.011
Significance	***	**	***	***

- *Differences in Growth Rate Among Tomato Cultivars for Plant Height, Main Stem Height, Stem Diameter and Leaf Area Index.*

The top three cultivars with highest growth rate were Cherry Little Wonder, Money Maker and Hot Stuff. Their growth from 3 weeks to 9 weeks was increasing at the exponential rate, thereafter the growth increasing at logarithmic rate until week 15. The cultivars with slow growth rate were Star 9065, Rodade and Heinz. Their growth rate was exponential from week 3 after transplanting to week 6, after which the growth rate increased at a logarithmic rate until it reached week 8. From the week 9, growth rate increased at an arithmetic rate until week 15. Fig. 1 below illustrated afore-mentioned growth pattern for plant height of eight cultivars.

The top three cultivars with tallest main stem were Cherry Little Wonder, Money Maker and Hot Stuff with their growth rate from week 3 to week 12 increasing at an exponential rate. From week 12 to week 15, their growth rates were increasing at logarithmic rate. Thereafter, arithmetic growth rate followed until senescence stage. The cultivars with shortest main stem height were Star 9065, Rodade and Heinz. Their growth rates also increased at an exponential rate from week 3 to week 12, after which the logarithmic growth rate was experienced from week 13 to week 15. Fig. 2 below illustrated afore-mentioned growth pattern for main stem heights for eight cultivars.

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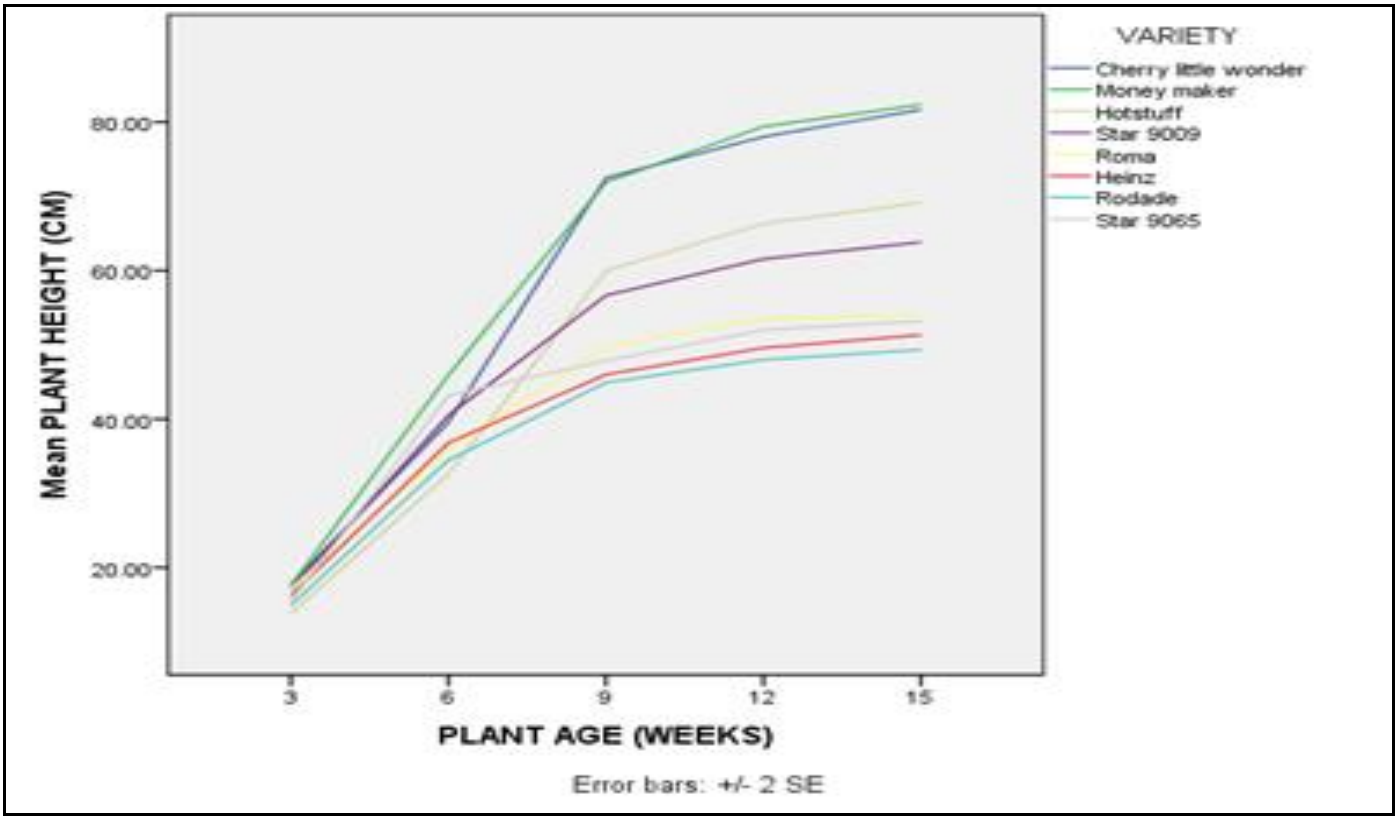

Fig 1 Mean Plant Height (CM)

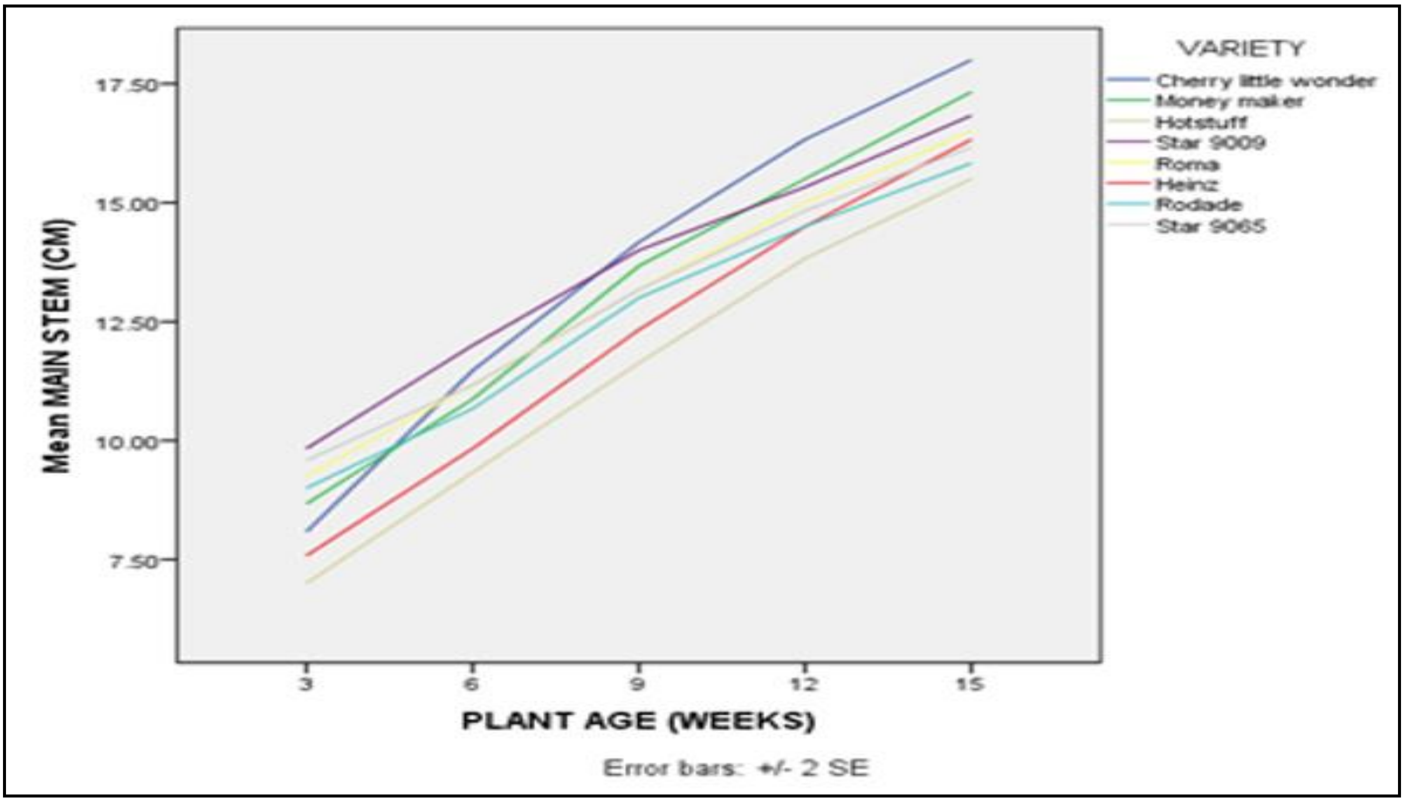

Fig 2 Mean Main Stem (CM)

Fig. 1 illustrated afore-mentioned growth rate for plant height of eight cultivars. Fig. 2 illustrated afore-mentioned growth rate for main stem height of eight cultivars.

The top three cultivars with biggest stem diameter were Roma, Star 9065 and Heinz. Their growth rate increased from week 3 to week 9 at an exponential rate, thereafter from week 9 to week 15, the diameter increased at a logarithmic rate. Cultivars with smallest stem diameter were Cherry Little

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Wonder, Money Maker and Hot Stuff. Their growth rate also increased at an exponential rate from week 3 to week 9, but increased at the logarithmic rate from week 9 to week 15. (Figure 3 illustrated growth rate in graphic form below).

The top three cultivars with highest leaf area index were Cherry Little Wonder, Hot Stuff and Star 9009. Their growth rate from week 3 to week 6 was increasing at an exponential rate, while from week 6 to week 15, the increase was at the logarithmic rate. Cultivars with lowest leaf area index were Roma, Star 9065 and Heinz. Their growth rate increased at an exponential rate from week 3 to week 12, thereafter their growth increased at logarithmic rate. The growth rate decreased at arithmetic rate from week 12 to week 15. Fig. 4 depicted these patterns.

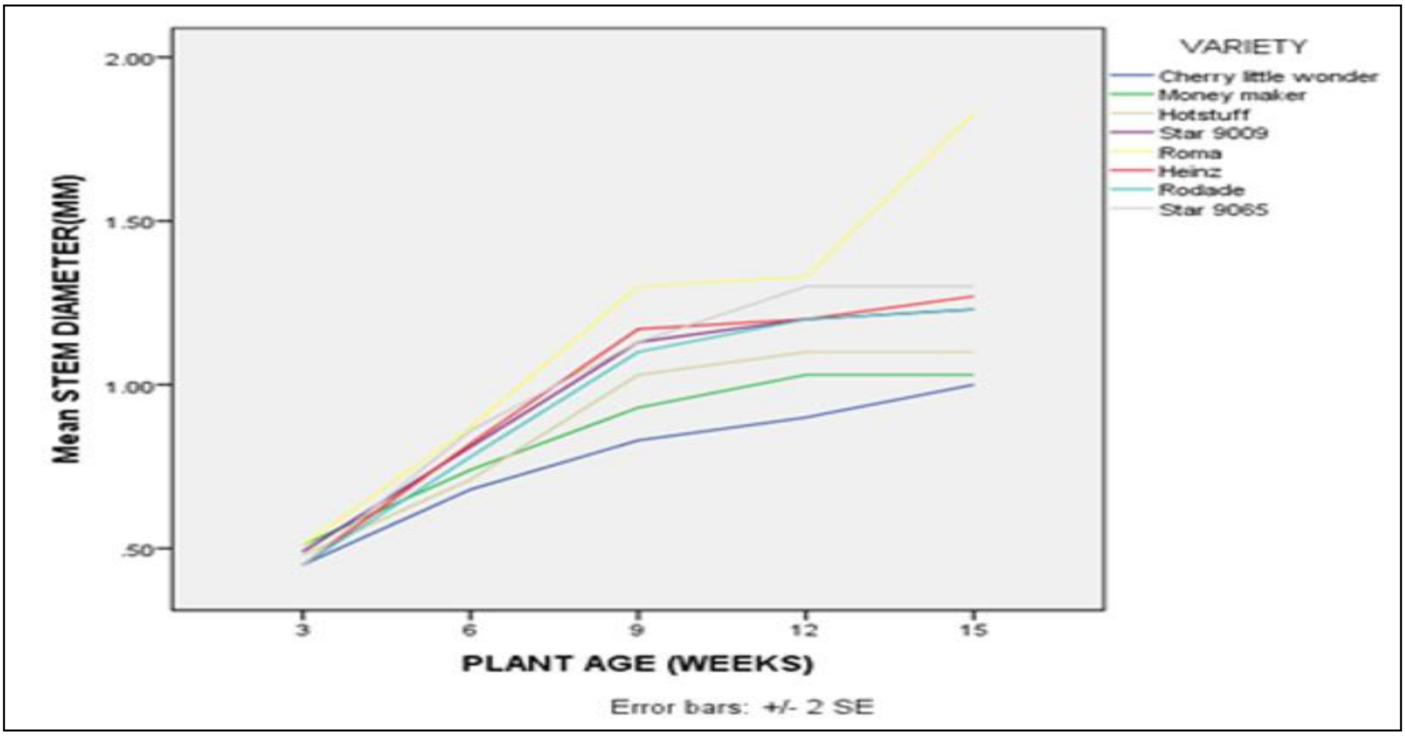

Fig 3 Mean Sten Diameter (CM)

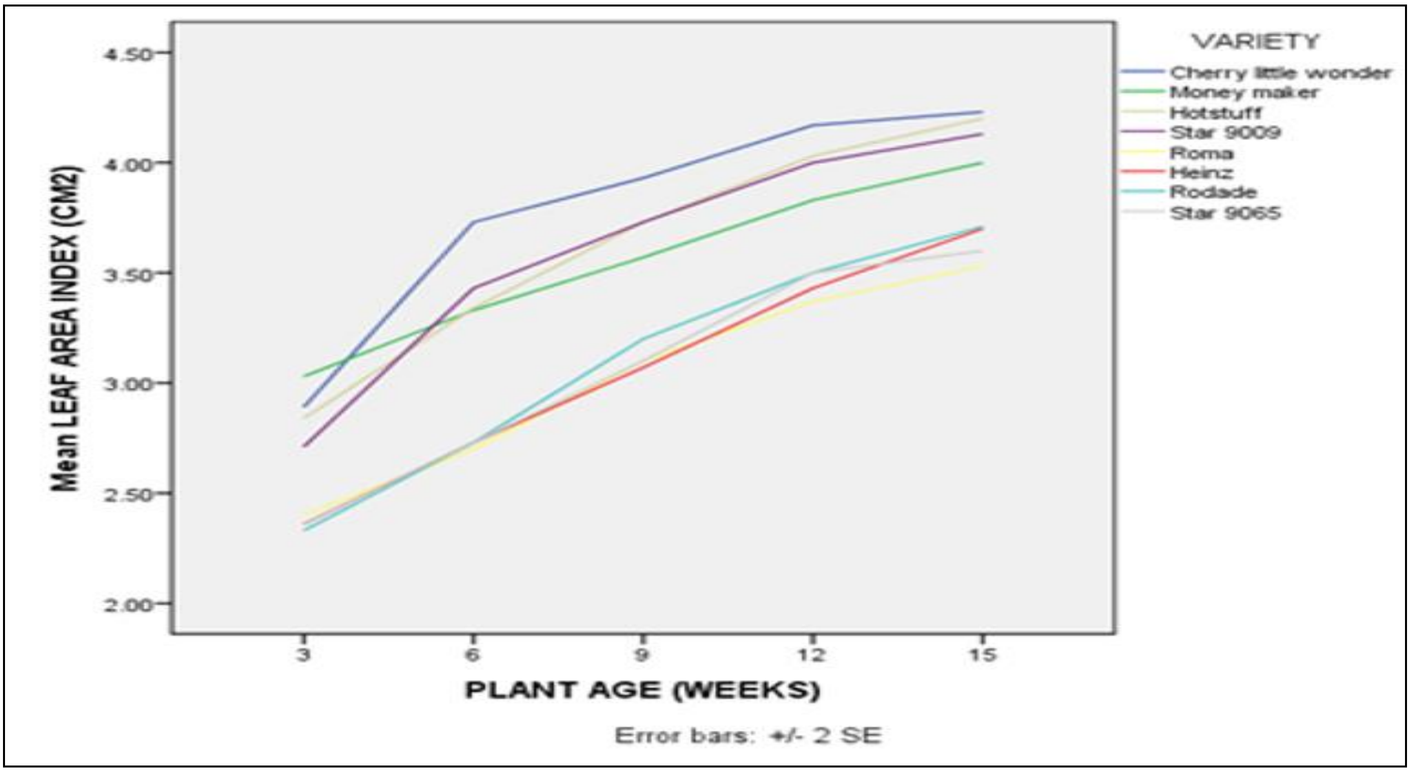

Fig 4 Mean Leaf Area Index (CM2)

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Fig 3. illustrated afore-mentioned growth pattern for stem diameter of eight cultivars. Fig 4. illustrated afore-mentioned growth pattern for leaf area index of eight cultivars.

➢ *Yield and Yield Components of Different Tomato Cultivars*

- *Differences Among Tomato Cultivars for Yield and Yield Components*

The main effects being cultivars and harvesting time showed highly significant differences (P<0.01) in plant population stand, number of fruits per plant, fruit weight, fruit diameter and marketable percentage per cultivars. There was a highly significant difference (P>0.01) in fruit length among cultivars, while no significant difference was obtained among cultivars for fruit length. Table 4 depicted the summary of the afore-mentioned. Furthermore, interaction between cultivars and harvesting time was highly significant in fruit weight (P<0.01) and significantly for marketable percentage per cultivars (P<0.05) (Table 4). The other parameters were non-significant. The models accurately accounted for variability of the yield parameters with R^2 values of over 0.95 except for the number of fruits per cluster (R^2 =0 .77).

Table 4 Summary of the Analysis of Variance for Yield Parameters

Source of variation	Df	Yield parameters								
		1	2	3	4	5	6	7	8	9
Cultivars (significant level)	7	N/A	NA	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Harvesting time (significant level)	2	N/A	N/A	N/A	0.000	0.000	0.000	0.983	0.001	0.010
Cultivars*Harvesting time (significant level)	14	N/A	N/A	N/A	0.775	0.963	0.003	0.709	0.275	0.013
Error	48									
Total	71									
R squared				0.772	0.975	0.959	0.957	0.990	0.995	0.998

*** Highly significant at p <0.001; * significant at p <0.05; N/S = Not significant (p>0.05); N/A = Not applicable; Yield parameters 1,2,3,4,5,6,7,8 designate: 1=Number of days to flowering, 2=number of days to set fruits, 3=Flowers per cluster, 4=Plant population stand, 5=number of fruits per plant, 6=fruit weight, 7=fruit length, 8=fruit diameter, 9=marketable percentage per cultivar, respectively.

- *Differences Among Tomato Cultivars for Yield Components and Yield*

There was high significant difference (P>0.001) among cultivars on flowers per cluster, plant population stand, number of fruits per plant, fruit weight, fruit length, fruit diameter, marketable percentage (Table 5). Cultivars with the highest mean of flower number per cluster were Cherry Little Wonder With 12.00, Money Maker with 8.00 and Hot Stuff with 7.67, while cultivars with lowest mean on flowers per cluster were Heinz with 5.00, Star 9009 with 5.33 and Roma with 6.00. Table 5 depict flowers per cluster. According to Meseret et al., (2012) [4], number of flowers per cluster is positively correlated with the number of fruits per cluster. The higher the number of flowers in a cluster, the more the tomato fruits. Thus, it is important in selection for improvement of fruit yielding potential of tomato cultivars. Compared to the other cultivars, more fruit yield would be expected from Cherry Little Wonder.

Cherry Little Wonder and Star 9065 expressed the shortest number of days to flowering as 35 days and shortest day to fruit set as 47 days. Hot Stuff and Heinz revealed the longest number of days to flowering at 39 and 38 days and longest days for setting fruit was 51 days for Hot Stuff and 50 days for Heinz, respectively (Table 5). The differences in the number of days to flowering and setting fruit observed in the cultivars was attributed to genetic constitution of each cultivar. Cultivars that had the same number of flowering of days and fruit set shared the same genes conferring the flowering days and fruit setting. Conversely, cultivars with different flowering and fruit setting do not share similar genes for these two afore-mentioned traits. Similar views were expressed by Abdelmageed and Gruda (2009) [24], who

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conducted an experiment with 20 cultivars of tomato and observed different number of days to flowering and fruit setting in these cultivars and concluded that it was because of genetic make-up since the environment conditions were the same. Singh *et al*., (2014) [25] carried out an investigation on different number of days to flowering and fruit setting and obtained similar results and group them according to these traits.

Tomato cultivars with the highest mean on plant population stand were Star 9009 with 8,890 plants, followed by Money Maker with 7,780 plants and, lastly Hot Stuff with 7,700 plants. Cultivars with the lowest mean on plant population stand were Star 9065 with 3,670 plants, Heinz with 5,670 plants and Roma with 5,890 plants (Table 5). The number of tomato plants transplanted were the same for all cultivars, but as they grew, some died, changing the population stand. Singh *et al*., (2014) [25] conducted an experiment on tomato cultivars in Bangladesh and found that even though the number of tomato plants transplanted were the same, the final population stands were different because of some which died. He attributed the death of the plant to their susceptibility to abiotic and biotic factors.

Cultivars with the highest mean on the number fruits per plant were Cherry Little Wonder with 60.78, Money Maker with 22.44 and Star 9065 with 22.11, while those with the lowest mean were Heinz with 10.11, Rodade with 11.22 and Star 9009 with 16.78 (Table 5). Higher number of fruits may be attributed to genetic make-up of these cultivars conferring high fruit number. Again, this trait is controlled by gene which some cultivars did not have. Similar variations in the number of fruits per cluster were reported by Traka Mavrona *et al* (1999) [26]. However, Wien (1997) [27] reported that greater numbers of fruits per plant decrease fruit size and soluble solids, while Ho and Hewitt (1986) [28] showed that high temperatures cause abortion of flowers and ultimately reducing number of fruits. This notion did not apply since all cultivars were exposed to the same environmental conditions, only cultivars were different, hence genetic make-up of the cultivars could be held responsible.

Cultivars with the highest mean on fruit weight were Star 9009 with 15.66 g, Rodade with11.09 g and Hot Stuff with 9.37 g. The lowest means were from Cherry Little Wonder with 1.14 g, Roma with 5.98 gm and Money Maker with 7.98 g (Table 5). This performance suggested that the cultivar could be efficient in capturing higher percentage of assimilate. The differences observed among the cultivars could be attributed to genetic make-up of individual cultivar and adaptability to the environment understudy. A similar finding was reported by Fontes *et al.* (1997) [29]. It would be anticipated that Heinz cultivars with less fruit weight should have the heaviest fruits because the amount of assimilates synthesized would be directed into few fruits. The assimilates were probably directed to other vegetative and reproductive parts other than in fruit weight. This scenario indicated that the combination of number of fruits and weight could improve quality through the increase of fruit weight and fruit size. These findings concurred with those of Jones (2007) [5] who reported that the size of the mature fruit is influenced by genetics, environment, and plant conditions during development of flower and fruit. The author further reported that conditions that reduce the amount of assimilate available tend to decrease the size of individual fruits.

The cultivar with the highest mean on fruit length were Star 9065 measuring 7.76 cm, Roma measuring 5.79 cm and Star measuring 9009 cm, while cultivars with the lowest mean were Cherry Little Wonder obtaining 3.12 cm, Money Maker obtaining 4.72 cm and Heinz obtaining 5.08 cm (Table 5). Ali (2020) [20] carried out a study researching on performance of tomato cultivars and its yield components including fruit length and found the average fruit length being 4.18cm. He asserted that the increased length of summer tomato might be due to synthesizing tryptophan and auxin that improve cell size or cell number.

Highest mean of fruit diameter was obtained from Star 9009 recording 6.97 cm, Heinz recording 6.34 cm and Rodade recording 6.33 cm, while Cherry Little Wonder (2.1 cm), Roma (4.41 cm) and Star 9065 (4.64 cm) had the lowest mean (Table 5). The variation in fruit diameter obtained from this study was in line with Tigist *et al* (2011) [21] who reiterated that the highest fruit diameter was 12.9cm roughly five to six fruits per plant. The fruit diameter depends on many factors including cultivar, foliar fertilization, crop load and weather conditions. The size of tomato in a truss is increased by thinning after the fruit set and the ability of plant to partition photo assimilates [29].

Among the eight tomato cultivars used for this study, the highest mean on marketable percentage were Star 9009 (85%), Star 9065 (82%) and Money Maker (75.72%), while those having the lowest mean were Rodade (65.89%), Hot Stuff (69.78%) and Roma (70.78%) Table 5 shows the means for all the parameters studied. Marketable fruit percentage is a determinant of fruit yield which is the major determinant variable for selection of a particular tomato cultivars, as it directly affects commercialization, thus, income generation of the farms [29]. There was a wide range of 66% to 85% on marketable fruit percentage among cultivars. This variation was also statistically significant ($p<0.01$). Star 9009, Star 9065 and Money Maker cultivars had the least number of fruits that were cracked, shrunken, small sized and discoloured, while Rodade and Hot Stuff had the most. Star 9009 and Star 9065 with the high marketable percentage were hybrid, determinate in growth habit and were for fresh market [30]. Money Maker is an open-pollinated, indeterminate heirloom [31]. The variation could be due to the differences in genetic make-up and or agro ecological adaptations of the cultivars.

In general, variation in the yield components of tomato in this study may be mainly due to genetic constitution of each cultivar and environment did not play any part since they all receive similar treatment. The results obtained in this study were within the range reported by Serrano *et al*. (2005), Ali (2020), and Hussain *et al*. (2001) [32; 20; 7].

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Table 5 Means of different cultivars on yield parameters

Variety	Treatment (Mean)								
	1	2	3	4	5	6	7	8	9
Cherry Little Wonder	35	47	12.00	6.44	60.78	1.14	3.12	2.10	76.56
Money Maker	36	49	8.00	7.78	22.44	7.98	4.72	4.97	75.22
Hot Stuff	39	51	7.67	7.78	18.89	9.37	5.26	6.34	69.78
Star 9009	36	48	5.33	8.89	16.78	15.66	5.66	6.97	85.00
Roma	36	51	6.00	5.89	17.22	5.98	5.79	4.41	70.78
Heinz	38	50	5.00	5.67	10.11	9.78	5.08	5.78	75.11
Rodade	37	49	7.67	7.78	11.22	11.09	5.22	6.33	65.89
Star 9065	35	47	7.00	3.67	22.11	8.01	7.76	4.64	82.00

Yield parameters 1, 2,3,4,5,6,7,8 designate:1= Number of days to flowering, 2=number of days to set fruits, 3=Flowers per cluster, 4=Plant population stand, 5=number of fruits per plant, 6=fruit weight, 7=fruit length,8= fruit diameter, 9=marketable percentage per variety respectively.

- *Effect of Harvesting Time on Yield Parameters*

Table 5 and 6 showed the effect of harvesting time on yield parameters. Plant population stand was significantly high (7.58) from 15 September harvesting and lowest (5.88) from 13 March harvesting possibly because more rain was received during the months of January and February (Fig. 5). However, the number of fruits per plant (27.21) (Fig. 7), single fruit weight (10.57) and % marketable fruits (77.29) (Fig 10) were significantly high ($P<0.01$) from 01 March harvesting. The lowest number of fruits per plant (21.04), single fruit weight (4.87) (Fig.9), fruit length (5.31) (Fig. 9), fruit diameter (4.90 cm) (Fig. 8) and % marketable fruits (73.21) (Fig. 10) were realized from 13 March harvesting.

The results were in line with those of Deribe *et al* (2016) [33] who obtained the highest number of fruits per plant and marketable percentage of fruits to be in the turning stage of tomatoes. In this study, production was higher but the fruits were exposed to too many defects leading to lower marketable percentage in late harvest. Similarly, the highest percentage of marketable fruits was from the middle harvest, and the highest fruit weight, length and diameter were from the first harvest when the number of fruits per plant was low.

Tomato cultivars differ in light and temperature requirements. Some required accumulation of a high number of heat units (growing degree days), while others require a low number of heat units to reach flowering stage, fruit setting, and other reproductive parts determining yield parameters. Similarly, length of light is required as it induces production of a hormone called florigen responsible for initiating flowering. The two afore-mentioned plays a vital role in determining components of yield indicated above [26]. The difference among and within the parameters of yield were wholly accounted for by temperature and light requirements of each cultivar.

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Table 6 Mean for effect of harvesting time on yield parameters

Harvesting time	Yield parameters (mean)								
	1	2	3	4	5	6	7	8	9
15 Feb (early)	36.50	49.00	7.33	7.58	19.08	10.44	5.35	5.38	74.62
01 Mar (middle)	NA	NA	NA	6.75	27.21	10.57	5.32	5.30	77.29
13 Mar (late)	NA	NA	NA	5.88	21.04	4.87	5.31	4.90	73.21
Total mean	NA	NA	NA	6.73	22.44	8.63	5.33	5.19	75.04
SD	NA	NA	NA	2.10	16.69	5.63	1.36	1.53	7.86
CV (%)	NA	NA	NA	31.20	75.27	65.24	25.52	29.48	10.47
Significance	NA	NA	NA	0.017	0.215	0.000	0.996	0.517	0.189

1=Flowering days, 2=Fruiting days, 3= Flowers per cluster, 4= Plant population stand, 5= Fruits per plant, 6= Fruit weight, 7= Fruit length, 8= Fruit diameter, 9= % Marketable fruits

- *Interaction Effects of Cultivars and Harvesting Time on Yield Parameters*

The combined effects due to different harvesting dates and different tomato varieties and their interaction on yield parameters are shown in Table 7.

The ANOVA (Table 4) showed that there were significant differences ($P<0.05$) among treatment means on cultivars and harvesting time on fruit weight and marketable percentage. This implied that these parameters were affected by an interaction of both cultivars and harvesting times. Conversely, there were no significant differences in means for other interactions. The interactions between cultivars and harvesting period for fruit weight and marketable percentage were not unusual because day and night temperatures can vary a lot in an interval of 14 days in which harvesting was done in this study. Daily temperature can fluctuate a lot within 24 hours in Lesotho. Temperature has a large influence on growth and development in tomato [33]. Also, cultivars used in this study were different genetically.

Harvesting in the middle (March 01) was superior than early (February 15) which in turn performed better than late (March 13) harvesting for fruit weight. The average fruit weight was 10.57, 10.44 and 4.87 gm for middle, early and late harvests, respectively. Harvesting in the middle (March 01) performed superior than early (February 15) which in turn performed better than late (March 13) harvesting for marketable percentage. The average marketable percentage was 77.29, 74.59 and 73.21 for middle, early and late harvests respectively.

The best fruit weight and the highest percentage of marketable tomato yield were recorded from the middle harvest largely due to reduced premature fruit drop as a result of poor weather conditions and low disease outbreak. In late harvest, there was an increase in defects, blossom scar, off shape and cracks on fruits due to frost at night which had negative effect on fruit weight and marketable fruit percentage. The highest weight of fruit per plant (22.17 g) and % marketable fruit (87.67%) was achieved by Star 9009 in the 01 March combination. This was followed by Star 9009 in the 15 February combination that resulted into fruit weight per plant of 18.10 g and 85% marketable fruits. The results obtained in the study were in line with those of Deribe *et al* (2016) [33] where the lowest yield was obtained in green harvest because the plant had not yet reached its peak period of production. The highest harvest was obtained when tomatoes were turning red which also corresponded with the period that the fruits were heaviest.

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Table 7 Combined Effect of Cultivar x Harvest time on Yield Parameters

Treatment	Yield parameters								
Cultivar * Harvesting time	1	2	3	4	5	6	7	8	9
Cherry Little Wonder * 15 Feb	35	47	12.00	6.67	58.00	1.17	3.17	2.13	75.67
Cherry Little Wonder * 01 Mar				6.33	69.00	1.10	3.13	2.03	83.33
Cherry Little Wonder * 13 Mar				6.33	55.33	1.17	3.07	2.13	70.67
Money Maker * 15 Feb	36	49	8.00	9.33	19.67	8.73	4.63	5.27	77.67
Money Maker * 01 Mar				7.67	28.33	9.23	4.83	5.40	76.00
Money Maker * 13 Mar				6.33	19.33	5.97	4.70	4.23	72.00
Hot Stuff *15 Feb	39	51	7.67	8.33	13.33	11.33	4.87	6.33	67.00
Hot Stuff * 01 Mar				7.67	24.67	10.80	5.50	6.83	75.33
Hot Stuff * 13 Mar				7.33	18.67	5.97	5.40	5.87	66.67
Star9009 *15 Feb	36	48	5.33	10.67	10.33	18.10	5.60	7.40	85.00
Star9009 *01 Mar				8.67	23.00	22.17	5.77	6.97	87.67
Star9009* 13 Mar				7.33	17.00	6.70	5.60	6.53	82.33
Roma * 15 Feb	36	50	6.00	6.33	13.00	6.70	5.93	4.37	72.33
Roma * 01 Mar				5.67	22.33	6.53	5.90	4.57	68.00
Roma * 13 Mar				5.67	16.33	4.70	5.53	4.30	72.00
Heinz * 15 Feb	38	49	5.00	6.33	8.33	12.63	4.93	6.20	74.67
Heinz * 01 Mar				6.33	13.33	12.20	4.80	5.53	73.67
Heinz * 13 Mar				4.33	8.67	4.50	5.50	5.60	77.00
Rodade* 15 Feb	37	47	7.67	9.00	9.00	13.83	5.20	6.43	63.67
Rodade * 01 Mar				8.00	12.33	13.73	5.47	6.60	74.00
Rodade *13 Mar				6.33	12.33	5.70	5.00	5.97	60.00
Star9065* 15 Feb	35	49	7.00	4.00	21.00	11.00	8.43	4.87	80.67
Star9065* 01 Mar				3.67	24.67	8.77	7.13	4.50	80.33
Star9065 * 13 Mar				3.33	20.67	4.27	7.70	4.57	85.00

1=number of days to flowering, 2=number of days to set fruits,3=flowers per cluster 4=Plant population stand, 5=fruits per plant, 6=fruit weight,7= fruit length, 8=fruit diameter, 9= marketable percentage per variety

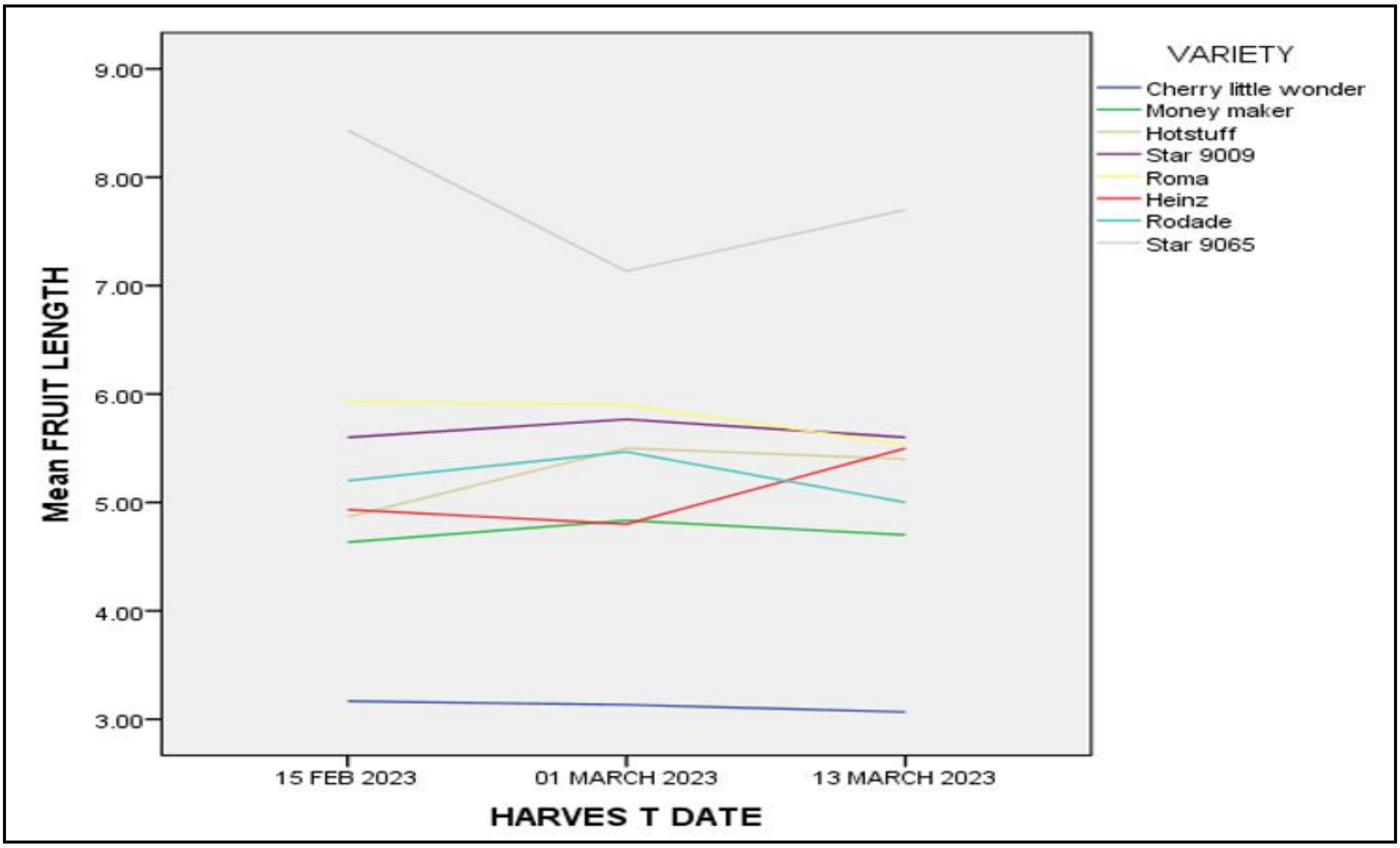

Fig 5 Plant Population Stand

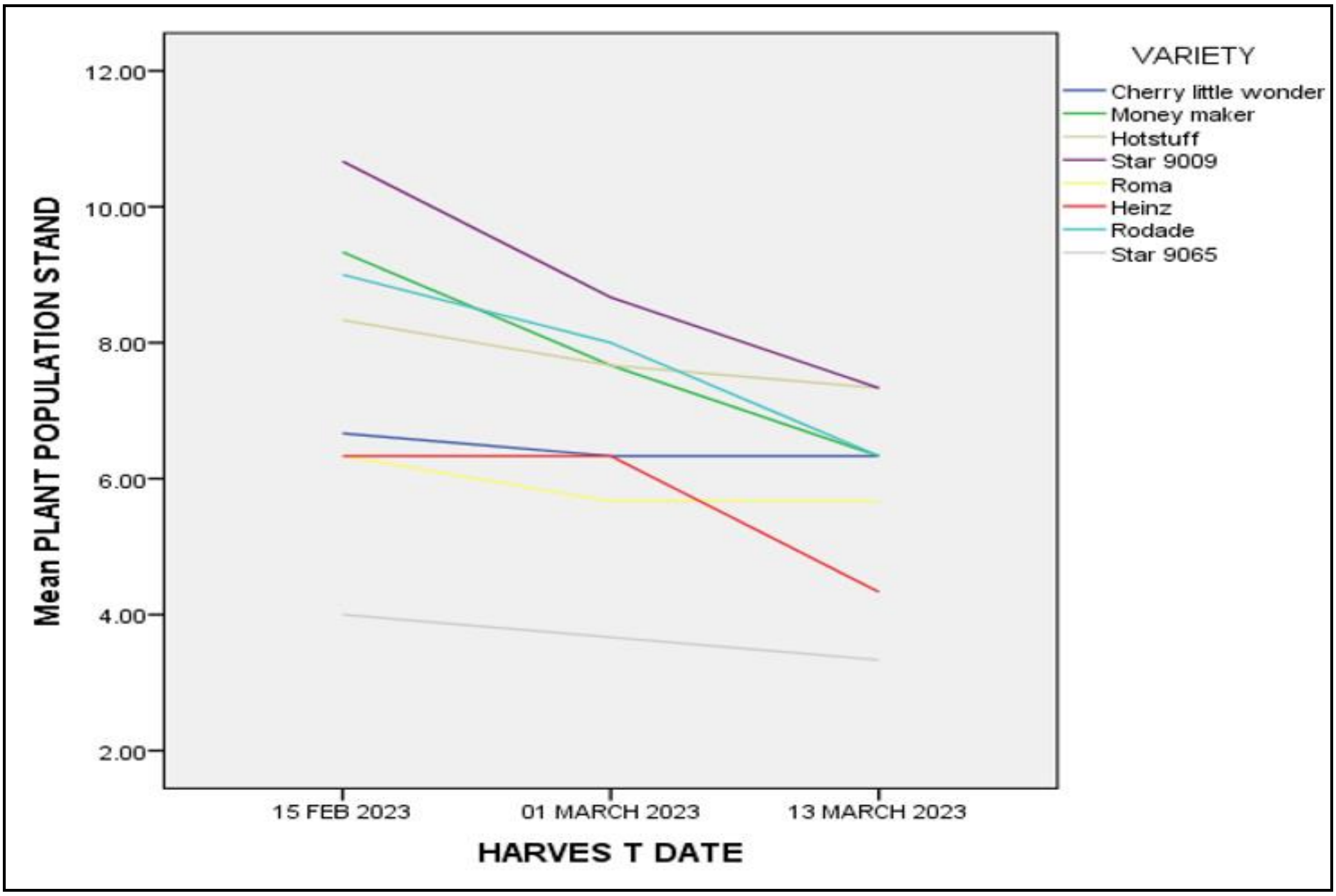

Fig 6 Fruit Length

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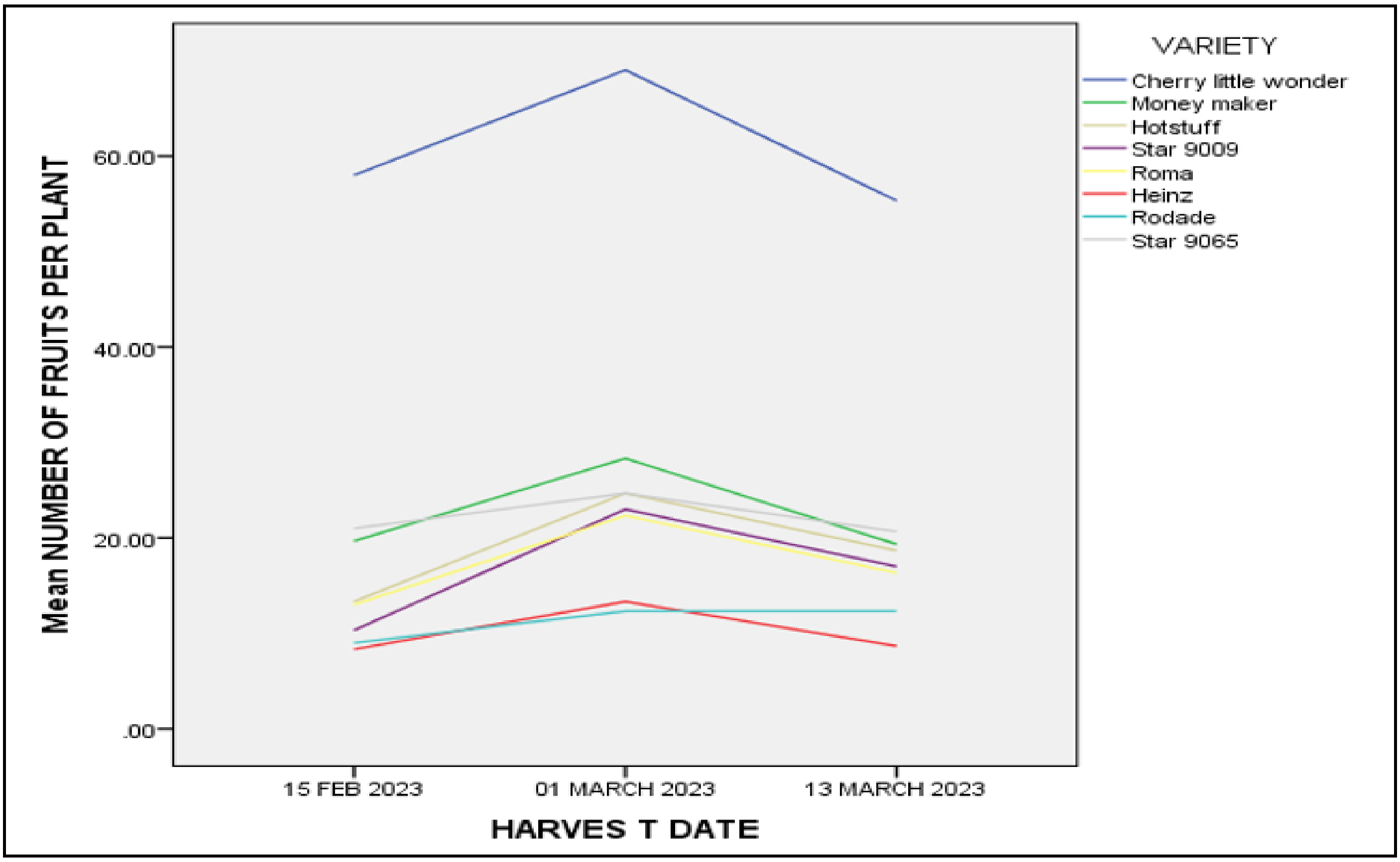

Fig 7 Number of Fruits Per Plant

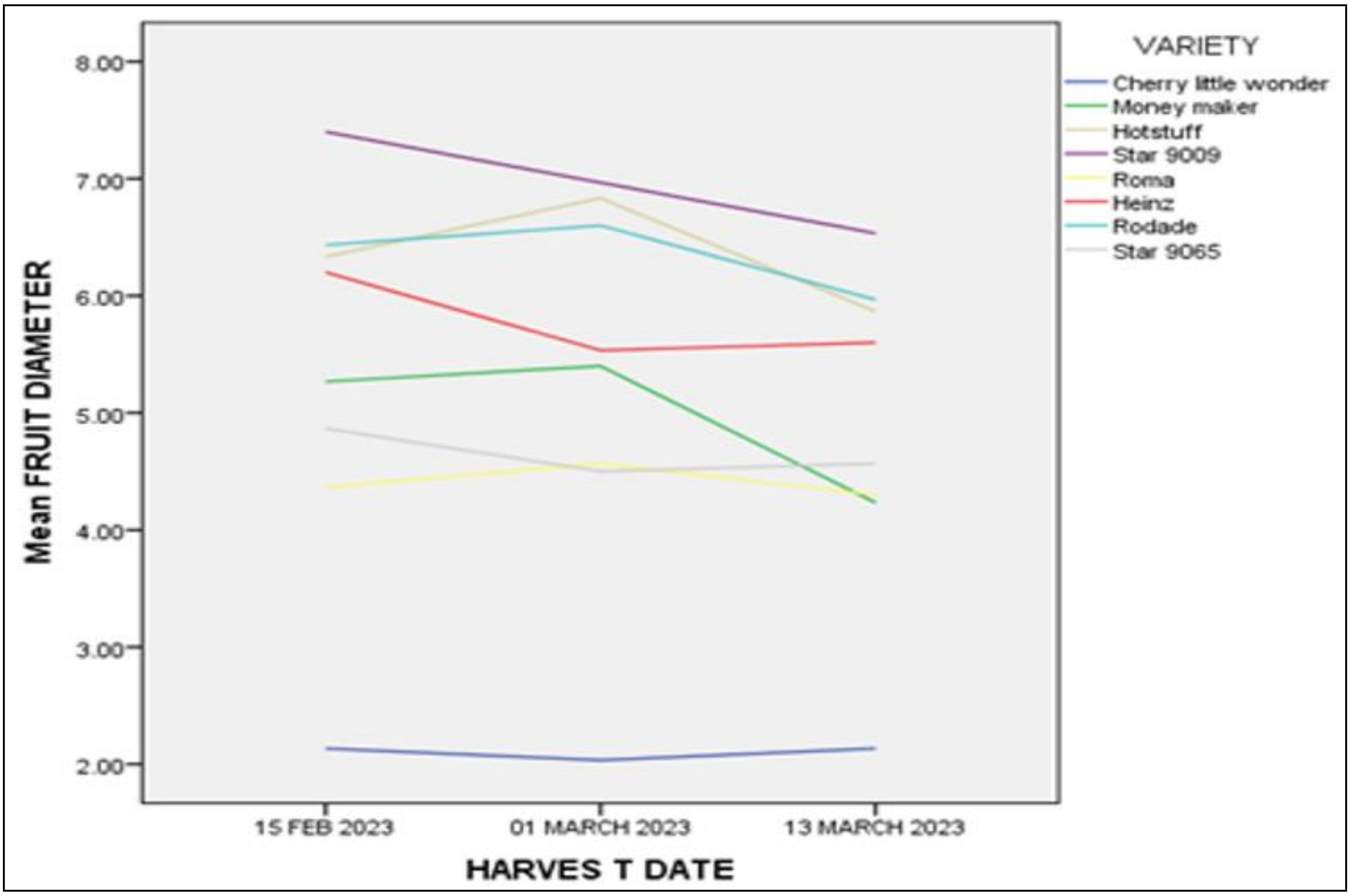

Fig 8 Mean Plant Diameter

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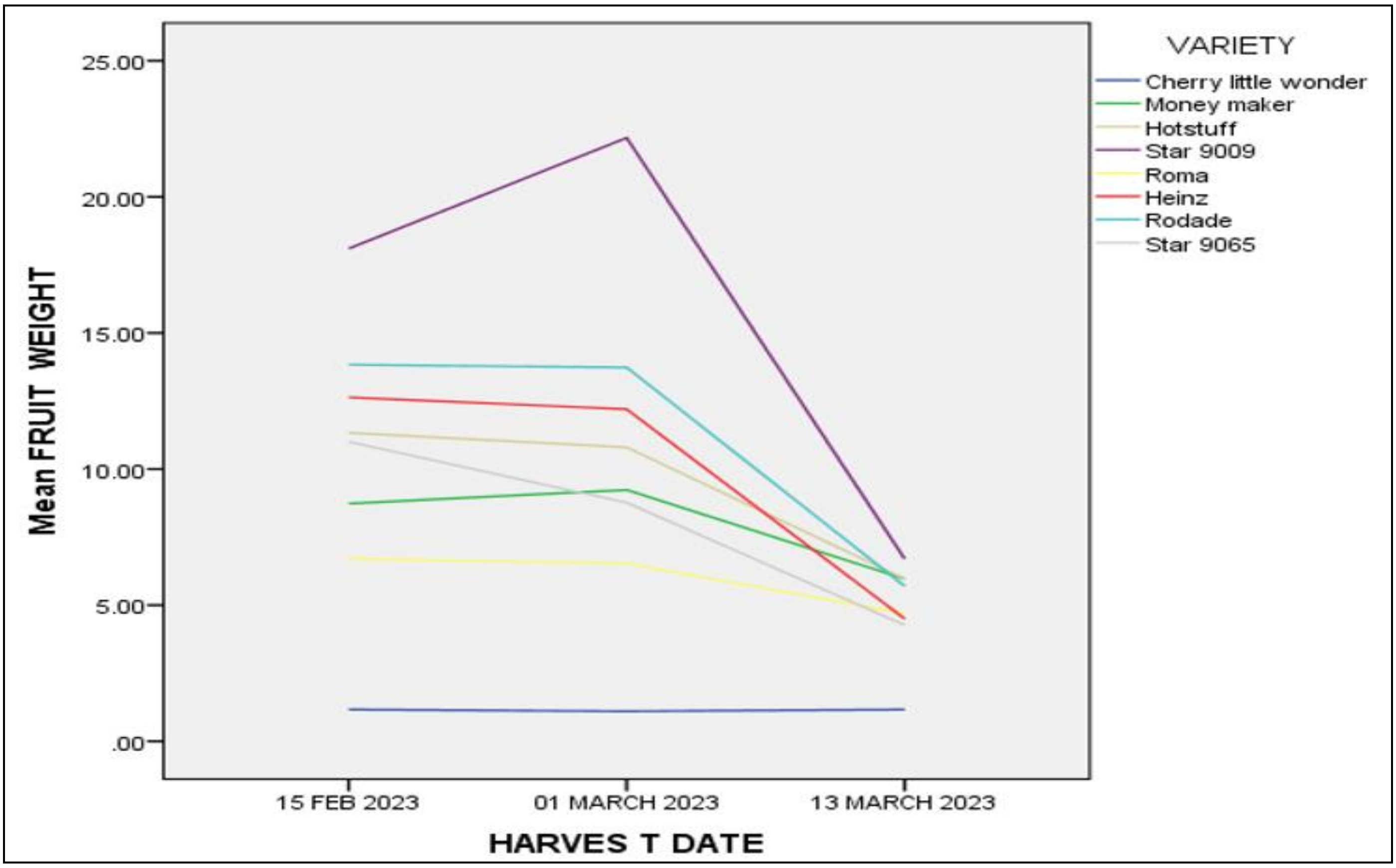

Fig 9 Mean Fruit Weight

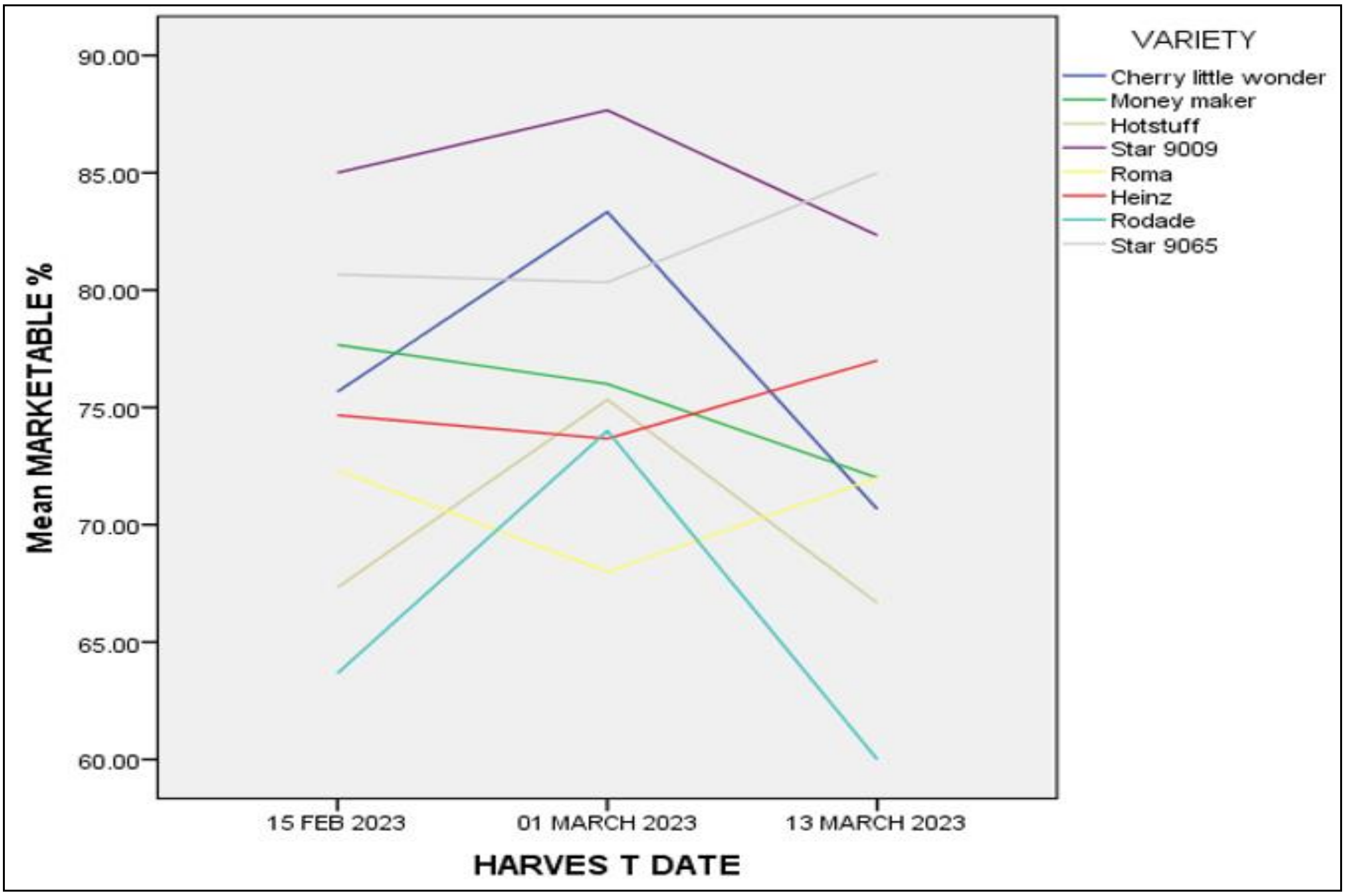

Fig 10 Marketable Percentage

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From the results, the highest production was obtained in the second harvest in all the eight cultivars. For indeterminate cultivars, the second highest harvest ranked 3rd, while for determinate, they ranked 1st. Almost six (6) of the cultivars had their highest weight, length and diameter of the fruits during 1st harvest and the highest marketable fruits in all cultivars was in the 2nd harvest.

➢ *Determination of Nutritional Value Among Tomato Cultivars*

- *Titratable Acidity*

There was high significant (P>0.05) difference among cultivars for titratable acidity (TA) (Table 8). The TA for the 8 cultivars studied ranged from 0.05 to 0.61. The cultivars with the highest mean were Cherry Little Wonder (0.61), followed by Roma (0.2) and, lastly Star 9009 (0.16), while cultivars with lowest mean were Money Maker (0.05), Hot Stuff and Star 9065 (0.09) (Table 9).

TA and pH are the most commonly used as acidity indicators of tomato [13]. TA in fruits of tomato cultivars varied between 0.14–0.46 % (Coefficient of variation = 28.4 %) with an average content of 0.28 %. The variations were attributed to differing cultivars with some cultivars conferring high TA and pH, others low TA and pH. The values obtained in this study were in agreement with those (0.10 to 0.41 %) reported by Anthon *et al*. (2012) [15] and Serrano *et al*. (2005) [32] for red, fresh tomato. The high value for Cherry Little Wonder is supported by Lokesha *et al*. (2019) [34] and Fikreyohannes and Bhalekar (2016) [35], who also reported that citric acid contributed to approximately 40-90% of the total acidity in the ripe tomatoes depending on the cultivar. The other cultivar in this study had low values. This may be due to the loss of citric acid as explained by Anthon *et al*. (2011) [15]. Overall, TA values were low which could also be due to the fact that the plants were grown in open field resulting in lower carbohydrate accumulation in the fruits. The variation could be due to variability in fruit size. Tittonell *et al*. (2001) [17] showed that large sized tomato fruit had higher acidity, which was in agreement with findings in this study.

Titratable acidity value greater than 0.35 has been suggested as desirable for processing tomato [35]. In this study, only Cherry Little Wonder achieved TA values greater than 0.35, indicating that it was the only cultivars among eight cultivars was good for processing.

- *Sugar Acid Ratio*

There was a significant difference among cultivars on sugar acid ratio (p>0.01) (Table 8). The cultivars with highest means were Money Maker (57.78). Rodade (48.90) and Heinz (40.21) (Table 9), while cultivars with lowest means were Cherry Little Wonder (5.27), Roma (13.98) and Star 9009 (20.47) (Table 9).

Besides Star 9009, the cultivars with high sugar ratio were all for fresh market while the ones with low ratio were for processing. This affirmed the notion that fresh market tomatoes contain better flavour than processing tomato cultivars. The index of sugar to acid was an indicator of the quality of the fruit and influenced flavour characteristics of processed tomato products [36]. The higher it was, the tastier the product. This suggested that sugar/acid content was a function of the cultivar genetic constitution [21].

- *Total Soluble Solids*

There was no significant difference among cultivars on total soluble solids (TSS) (Table 8). The cultivars with highest mean were Rodade (4.06), Heinz (3.53) and Star 9065 (3.2), while cultivars with lowest total soluble solids were Roma (2.63), Money Maker (3.03) and Hot Stuff (3.06) (Table 9).

The TSS is a refractometric index that indicates the proportion (%) of dissolved solids in a solution [16]. It is the sum of sugars (sucrose and hexoses; 65%), acids (citrate and malate, 13%) and other components (phenols, amino acids, soluble pectins, ascorbic acid and minerals) in the tomato fruit pulp that all together reach 78% of the total content [16].

Table 8 Summary of Analysis of Variance for Nutritional Mean Squares

Source	Df	Titratable acidity	Sugar acid ratio	Total soluble solids	Lycopene	% ash content	Moisture content
Cultivars	7	0.099***	949.390**	0.542	0.028***	0.088***	57.110
Error	16	0.002	203.525	0.220	0.000	0.000	51.113
Total	23						

*** Highly significant at p <.001; ** Significant at p <.01; N/S – Not significant (p>0.05); Df = Degree of freedom

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The TSS contents of fruit is one of the major criterions in selecting tomato cultivars for fresh market as it determines the sugar and acid content of a fruit that influences the overall flavour of the fruit.

The findings in this study agreed with the report that cultivars have effect on the TSS content [16]. In general, the values commonly obtained for soluble solids of different cultivars of tomato fruit range from 4 to 6 ºBrix [37]. Only Rodade (4.06) performed within this range. Most of the cultivars were slightly above 3 ºBrix. Low TSS of tomato fruits could be due to reduced moisture loss which decreases concentration as well as the hydrolysis of carbohydrates to soluble sugars [11]. The variation of TSS among the cultivars could be due to the genetic constitution of the cultivars since growing environment and management were the same, only cultivars differed. This is in agreement with Quadir *et al*., (2006) [31]. Moreover, tomato TSS is mostly composed of reducing sugar. Thus, any factor, like seasonal climatic variation as typical in Lesotho and horticultural practices that alters sucrose synthesis (photosynthetic activity) affects glucose and fructose accumulation in the fruits and TSS (Ho and Hewitt, 1986) [28].

- *Lycopene*

There was high significant difference among cultivars on lycopene (P>0.001); Table 8). The cultivars with the highest lycopene content were Heinz (0.38), Rodade (0.36) and Star 9065 (0.28), while cultivars with lowest lycopene were Roma (0.11), Hot Stuff (0.17) and Cherry Little Wonder (0.18) (Table 8).

The cultivars such as Heinz, Rodade and Star 9065, with higher values were in the range of those reported by Jones (2007) [5] who found that the optimum temperature for pigment synthesis is 16-21˚C, while temperature above 30ºC significantly reduces lycopene and carotenoid synthesis. However, Jones (2007) [5] found the highest lycopene and red colour accumulation to be at 24ºC during the day and 14 ºC during the night. Similarly, Alda *et al.* (2009) [38] showed that the content of lycopene of fresh tomatoes was approximately 12 mg/ 100 g which was in the range achieved by Roma, Hot Stuff and Cherry Little Wonder cultivars. The variation of lycopene content across different environments is possibly due to genetic differences in the cultivars, maturity ripening stage, fruit colour (Hart, 1995) [30] and growing environment. The differences between the cultivars could be very large, including the differences within the fruit colour groups. Kurina *et al*, (2021) [39] reported that cultivars with pink and orange-red colour of fruits were characterized by a high lycopene content (on average 26.32–32.52 mg/100 g). Cultivars with green-yellow, yellow and yellow-purple colour of the fruit accumulated significantly less than 6.5 mg/100 g. Hart (1995) [30] reported a 10-fold lower content (5 mg/kg) of lycopene in yellow colour of tomato compared to intensive red colour (50 mg/kg) on tomato cultivated in Great Britain. The content of lycopene in tomatoes also depends on the period of harvest as reported by Górecka *et al*. (2020) [23] based on the results of fresh tomatoes in Poland harvested in August that contained 31% more lycopene than those harvested in September.

- *Ash Content*

There was high significant difference (P.> 0.001) among cultivars for ash content (Table 8). Cultivars with the highest ash content were Roma and Rodade (0.59) and Money Maker (0.45), while cultivars with low ash content were Rodade (0.19), Star 9009 (0.21) and Star 9065 (Table 9).

The ash content refers the total crude minerals in a tomato fruit. Roma and Heinz had the highest ash content value falling in the range of 0.47% - 0.98% as reported by Agbemafle *et al.* (2015) [40]. Plants accumulate these nutrients through absorption by roots in the medium of water, thus this action decreases especially in water-stressed plants [41]. The highest ash content reflects the ability of the cultivars to absorb minerals from the soil [40]. Minerals have an effect on pH and titratable acidity, thus, influence the taste of the tomato fruit.

- *Moisture Content*

There was no significant difference among cultivars for moisture content (Table 8). The percentage moisture content (MC) of eight cultivars ranged from 77.77% to 90.6%. The cultivars with the highest moisture content were Star 9065 (90.6%), Hot Stuff (86.67%) and Roma (86.63%), while cultivars with lowest moisture content were Cherry Little Wonder (77.77%), Money Maker (78.17%) and Rodade (82.46%) (Table 9).

The average moisture content of tomato is about 95% [42]. The very high content makes them deteriorate in quality very fast because of chemical and microbiological effects which would be a disadvantage to cultivars with high water content because of reduced shelf life. The values obtained in this study were moderate in scale and were in consistent with those reported by Ali *et al.* (2020) [20] who found moisture range of 68.03-96.17% with a mean of 91.18 in tomato cultivars. Nonetheless, cultivars that naturally have lower values like Cherry Little Wonder, Money Maker would be suitable for making sauces.

Table 9 Mean Values of Nutrition Parameters of Tomato Cultivars

Cultivars	Parameters					
	Titratable acidity	Sugar acid ratio	Total soluble solids (°Brix)	Lycopene	Ash content	Moisture content
Cherry little wonder	0.61	5.27	3.20	0.18	0.41	77.77
Money maker	0.05	57.78	3.03	0.19	0.45	78.17
Hotstuff	0.09	40.21	3.06	0.17	0.23	86.67
Star 9009	0.16	20.47	3.13	0.24	0.21	84.73
Roma	0.20	13.98	2.63	0.11	0.59	86.63
Heinz	0.11	32.60	3.53	0.38	0.59	83.73
Rodade	0.11	48.90	4.06	0.36	0.19	82.46
Star 9065	0.09	37.06	3.20	0.28	0.22	90.60

V. CONCLUSION AND RECOMMENDATIONS

The results of the study revealed that there were highly significant differences among eight tomato cultivars for growth rate, yield and yield components, and nutritional value. The cultivars with the highest growth rate were Cherry Little Wonder, Money Maker and Hot Stuff. They commenced growth from week 3 to week 9 at an exponential rate, after which growth occurred at logarithmic rate until week 15. Beyond week 15, they grew at arithmetic rate to harvesting time. Tomato yield was highly influenced by plant population stand, number of fruits in a plant, fruit weight, fruit diameter, and marketable percentage per cultivar. In regard to nutritional value for different cultivars, Cherry Little Wonder, Money Maker, Rodade, Heinz and ash content had the highest titrable acids, sugar acid ratio, total soluble solids, lycopene and ash content, respectively. It can be concluded that Cherry Little Wonder, Rodade and STAR 9065 were ranking high in most of the parameters studied. With these results, it is recommended that they be evaluated under different environmental conditions.

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