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Physiological Responses and Nutritional Composition of Two Tomato (*Lycopersicum esculentum*) Cultivars-Roma-VF and IFE-1

Emmanuel A. Oguntola
Department of Biology, Federal University of Technology Akure, Nigeria

Foluso Ologundudu*
Department of Biology, Federal University of Technology Akure, Nigeria

Idris Saheeb Oladele
Department of Science Laboratory Technology, Federal Polytechnic Ede, Osun-State, Nigeria

Abstract

This work investigates the growth and physiological responses of locally grown tomato cultivars with a known hybrid (Roma-VF cultivars). Seeds of two tomato cultivars: Roma VF (*Lycopersicum esculentum* Mill.Cv) was collected from National Horticulture Research Institute (NIHORT), Ibadan while the Local tomato: Ife-1 (*Lycopersicum esculentum* Mill. Cv) obtained from the market woman in the central market, Obafemi Awolowo University, Ile- Ife. The seed of the plant were planted in perforated plastic containers containing soil collected at the base of hill 1(latitude 7°3'9.40 and longitude 4°3'24.52) in Obafemi Awolowo University Ile-Ife, Osun State. The containers placed where they can have access to direct sunlight. The growth parameters of the plants were determined which include the leaf length, width and the shoot size was observed. The weight and growth rate of the shoot were determined. The fruits obtained from all the cultivar were exposed to proximate analysis. It was observed that the shoot of the two cultivars increased in the course of the experiment but at the end the shoot of Roma () was longer than that of local cultivar. More number of leaves was present in Roma compare to local one. Roma has higher moisture content (5.9% M.C)) than the local cultivar (4.7% M.C). Average number of fruits in Roma was (15) which is higher than that of local one (10). From all the parameters observed in this work it was observed that Roma cultivar which is a hybrid do far better in all indication than the local tomato cultivar. This may be as a result of Roma hybrid characteristics such as resistances to disease and unfavorable environmental factors. Equally the improved nutritional value of the Roma tomato and lot of genetically modified features are key to this cultivar (Roma) advancement.

Keywords: Cultivar; Environmental; Lycopersicum; Nutrition; Tolerance.

1. Introduction

Like animals, stress also affect the efficiency and viability of plants. Plants are consistently exposed to various types of stresses which eventually tell on their production and stamina. Most of this stress are directly or indirectly occur from interactions of abiotic factor such as low or high temperature, relative humidity, wind, water potential, drought and others with the plant. Stress is a severe condition in plant which is as a result of climatic and environmental factors. This may not benefit the plant that is involved which may directly affect the plant productivity, disease resistance and also cause shedding of flower, poor growth, unhealthy look, and changes in leaf [1]. This condition will also tell on the physiology and anatomical make up of such a plant. Many plants are developing ability to cope with stress. Tomato (*Lycopersicum esculentum*) like other plants undergoes stress in its relationship with abiotic factors in the environment. One of the most worlds known vegetable is tomato (*Solanum lycopersicum*). It is a common household ingredient required in daily food meal due to the presence of anti-oxidative and anti-cancer properties of its major component lycopene. Tomato contains Lycopene which is a major content of tomato which play a major role in biosynthesis of carotenoid which is antioxidant responsible for the redness of a tomato fruit. There is an increase in the daily intake of tomatoes which directly contributed to its increase in demand by the household. Currently the amount produced is not yet able to meet the world demand for tomato [2]. In 2013 tomato was ranked 7th in global production in which approximately 164,000,000 million tones was produce on about 4.8 million hectares of land [3]. Tomato is a tropic plant and it can relatively adapt to many climatic factors in the world. Many factor ranging from biotic and abiotic affect the rate of production of tomato. Various pests also feed on the tomato plant or fruit which constitute a severe damage on the plant and eventually affect the plant yielding ability**.** Tomato is known to be good in preventing prostate cancer. Also extract from Tomato, known as Lycomato, is currently used in treating of high blood pressure. The high acidic content of the tomato make it is easy to be caned and producing paste or. Both ripe and unripe fruit of tomato can be eaten. Report from genetic and technological research showed that Lycopene play a major role in attending to heart related disease and digestive channel. Lycopene is the predominant carotenoid pigment of tomato that contributes to its characteristic red colour. It also

*Corresponding Author

functions as an antioxidant and helps in lowering DNA damage, malignant transformations and other parameters of cell damage and reduces cancer risk [4, 5].

2. Materials and Methods

Seeds of two tomatoes cultivars: Roma VF (Lycopersicum esculentum Mill.Cv) was collected from National Horticulture Research Institute (NIHORT), Ibadan. Local tomato: Ife-1 (Lycopersicum esculentum Mill. Cv) obtained from the market woman in the central market, ObafemiAwolowo University, Ile- Ife.

3. Germination of Seeds

Sand was collected at the base of hill 1(latitude 7˚3˙9.40 and longitude 4˚3˙24.52)in Obafemi Awolowo University Ile-Ife,Osun State. The sand was transferred into twenty plastic pots with size 21cm in depth and 21cm in diameter, containing bored holes at the bottom to allow for drainage during the course of the experiment. The potswere filled near brim with the sand.The pots were arranged in two rows, ten pots in each row. The seeds of the hybrid (Roma) were planted in one row while the seeds of the local type were planted in the second row. After germination, seedlings were transplanted to those pots where germination did not occur after which the seedlings were thinned down to one in each pot. The seedlings were raised under direct sunlight during the course of this experiment, they were watered daily and the experiment was repeated under the same condition.

4. Measurement of Morphological Parameters

A metric rule was used to measure the following morphological parameters. Leaf length and width; shoot height from the surface of the soil to the terminal end. The total number of leaves per plant was counted and recorded. For the fresh weight determination, plants were carefully uprooted and the soil attached to the roots washed off with tap water. The fresh weight of plant was then taken on a weighing balance after which it was dried in a Gallemkamp oven at 80^0C until a constant weight was achieved. After cooling, the dry weight was determined. The dried samples were then separated into leaves, stems and roots and their different weights determined .These were then kept for further analysis.

5. Growth Analysis

The following growth parameters were determined from the data obtained from the physical parameters.

5.1. Leaf Area (LA)

LA= L×W x 2.325 Osei-Yeboah and Vamos-Vigyazo [6]

The unit is cm^2, L and W are leaf length and width respectively while 2.325 is the correction factor.

5.2. Fresh and Dry Weight

The number of fruits were counted and recorded; the fruits were allowed to ripe and then plucked. The fresh weight is then determined by means of a weighing balance (Mettler P 203 Top Loading balance) and then recorded. The ripe fruits are then dried in an oven until a constant weight is obtained for the determination of the dry weight which is described below;

$$RWC = \frac{FW - DW}{FW} \times 100$$ Sumithra*et al* (2006)

5.3. Fruit Parameters

The shapes of the fruits, longitudinal (stem→blossom end) cross-sectional diameters (transverse diameter) were compared. Fruits were randomly selected and the average fruit weights were recorded.

The size of the fruit was determined using a vernier caliper to the nearest 0.01mm. The diameters were measured along the longitudinal (stem to blossom end) and cross-sectional axis (transverse diameter). Twenty-five fruits from each cultivar were randomly selected for measurements and the main value was evaluated as described by Viswanathan, *et al.* [7].

5.4. Proximate Analysis

This is a special scheme designed to know a considerable number of nutrients that are present in feedstuff and required by animal. A feedstuff is portioned into six different fractions namely:

1. Moisture
2. Ash
3. Crude Fibre
4. Crude Protein
5. Ether Extract
6. Nitrogen Free Extracts

6. Determination of Moisture Content

2g of sample was weighed into crucible which is made up of platinum or ceramic. It was transferred into hot-air oven and dried overnight at seventy degree Celsius. It was removed and allowed to cool in a dessicator. The final weight of the sample was taken with the aid of a mettler Toledo analytical balance.

Calculation:

$$\% \text{ moisture} = \frac{\text{initial weight in gram} - \text{final weight in gram}}{\text{Weight of sample taken in gram}} \times 100$$

7. Determination of Ash Content

2g of sample was weighed into a crucible which is made up of platinum or ceramic (it is important to know the weight of the empty crucible before taken the weight of the sample). It was transferred into a murffle furnace and ash at 600℃ for 3 hour. It was removed and allowed to cool in a dessicator. The final weight of the sample was taken with the aid of mettle Toledo analytical balance.

Calculation:

$$\% \text{ Ash} = \frac{\text{weight of empty crucible + ash} - \text{weight of empty crucible (g)}}{\text{Weight of sample taken(g)}} \times 100$$

8. Determination of Crude Fibre

This is determined by acid/base method. 2g of sample was weighed into a 600ml beaker(made up of Pyrex). 200ml of 1.25% H_2SO_4 was added, it was boiled on a hot plate and reflux for 30 minutes. (The beaker was covered with a mini-condenser containing some cold water to prevent 1.25% $H_2SO_4$from evaporation).

It was filtered with a sieving cloth and washed with hot distilled water to remove the acid. The sample was scraped with the aid of a spatula to the beaker. 200ml of 1.25% NaOH was added. It was boiled on a hot plate and reflux for 30 minutes.

(The beaker was covered with a mini-condenser containing some cold water to prevent 1.25% of NaOH from evaporation). It was filtered with a sieving cloth and rinsed with hot distilled water. The sample was scraped with the aid of spatula into a crucible. It was transferred into the hot-air oven and dried overnight at 70ºC. It was removed and allowed to cool in a dessicator. The weight of the sample was scraped with the aid of a mettlerToledos analytical balance and transferred into a murffle furnace for ignition. It is ash at 600ºC for 3 hours. It was removed and allowed to cool in a dessicator. The final weight of the sample was taken with the aid of a mettle Toledo analytical balance.

Calculation:

$$\% \text{ Crude fibre} = \frac{\text{Initial weight(g)} - \text{final weight(g)}}{\text{Weight of sample taken(g)}} \times 100$$

9. Determination of Ether Extract

This is determined by soxhlet extraction method. Fit up a soxhlet extractor with a reflex condenser and a small flask which has been previously dried in the oven and weighed. 2g of the sample was weighed into a “fat-free extraction thimble”. Plug lightly with cotton wool and place the thimble in the soxhlet extractor and add 125ml of Normal-hexane until it siphons over once. Replace the condenser, and see that the joints are tight and place on a water bath. The condenser is connected to the tap water and flows for 3 hours (that is, move in and out for 3 hours). The control on the water bath was adjusted to 50ºC so that the N-hexane is just short of siphoning over. Remove the thimble and recover the solvent (N-hexane). The flask (which contains all the oil) was detached and the exterior was cleaned and dried in the hot-air oven to a constant weight at 70ºC overnight. The final weight of the flask and oil was taken with the aid of mettler Toledo analytical balance.The thimble was dried in the oven and the extracted residue was kept for crude fibre determination. The thimble can be used for the determination of ether extract of another sample. % ether is also referred to as % fat, % oil or % lipid.

Calculation:

$$\% \text{ ether extract} = \frac{\text{Weight of flask+ oil (g)} - \text{weight of flask (g)}}{\text{Weight of sample taken (g)}} \times 100$$

% Nitrogen free extract (%NFE) = 100 – (%moisture + %ash + %crude fibre + %ether extract + %crude protein)

Total Carbohydrate = (%NFE+ %crude fibre)

10. Determination of Percentage Crude Protein

This entails three different stages that is digestion, distillation and titration

DIGESTION: Weigh 0.5g (of dry sample), 3g (for urine & milk) and 2g (for honey) of the sample into Kjeldahl digestion flask, add a little scoop of digestion catalyst/mixture which consists of anhydrous $CuSO_4$ (blue)- 50g, anhydrous K_2SO_4/ Na_2SO_4 – 500g and Selenite Mercury oxide (HgO) – 0.5g OR Mercury oxide (HgO) – 0.5g and Iron sulphate – 0.5g, add 20mlof concentrated H_2SO_4 carefully and transferthe flask into Kjeldahl digestion

system(Tecator digestion system 1007digestion) and heat or digest the mixture for 2 hour, cool and make the mixture up to 50ml mark with distilled water.

10.1. Distillation

Measure 50ml of 2% boric acid (plus indicator i.e. methyl red and bromocresol green) into 250ml Erlemeyer/Conical flask, place the flask under the receiving tube of the distillation unit in a way that the end of the tube is below the level of the H_2BO_3, measure 20ml of the sample into the Kjeldahl digestion flask, add very carefully, without shaking the flasks, 50ml of 40% NaOH into the Kjeldahl distillation flask which contains the sample.

10.2. Titration

Titrate the distillate with standard HCL i.e. a known concentrated amount of HCL/N-HCL, 0.097 N-HCL etc. until the end point is reached when there is a clear fluidcolour change. Titer value i.e. the net volume of acid used.

Table-1.

Sample	Weight(g)	Flask no	Acid concentration	Dilution factor(DF)	Initial reading	Final reading	Titre value
A	0.5	X	0.1	2.5	0.00		

Calculation:

$$\%N \text{ in sample} = \frac{\text{Titre value} \times \text{concentration of acid} \times 0.014 \times \text{dilution factor} \times 100}{\text{Weight of sample taken}}$$

% Crude protein = 6.25 × % N in sample

For milk and milk product, use the factor 0.38 – lactic acid – CH_3COOH.

10.3. Statistical Analysis

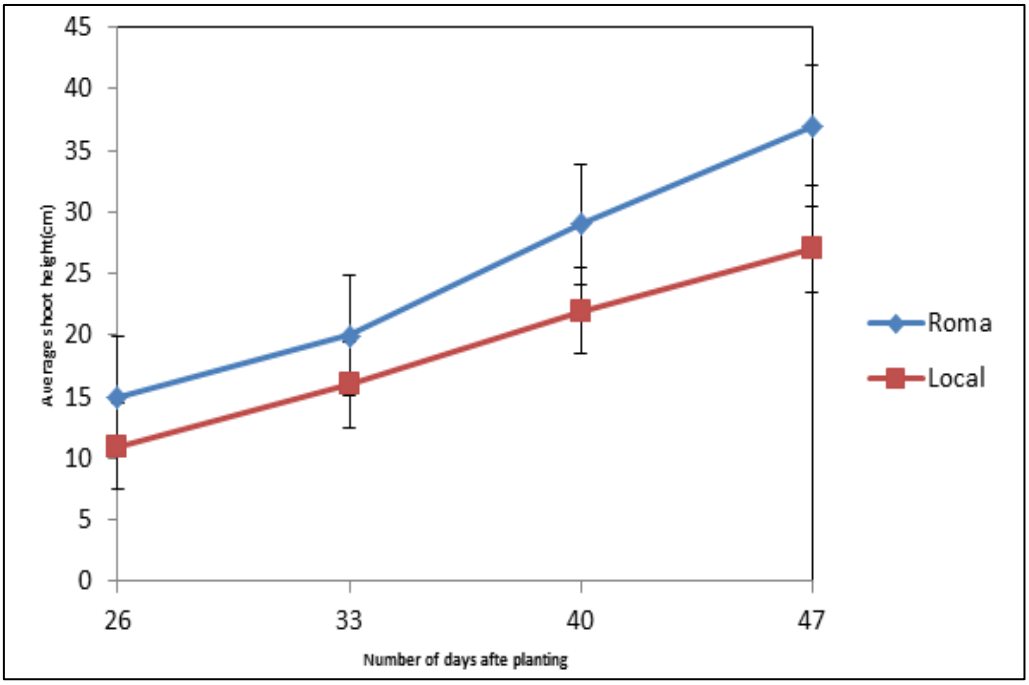
Statistical analysis was performed using Statistical Package for Social Sciences(SPSS) software version.The data were first tested between normality and assumption of constant variance. A one-way analysis of variance (ANOVA) was carried out, yield of the tomato plant. Since all the plants in the different cultivar were subjected to the same conditions,any observed differences in the parameters investigated between the plant can therefore be attributed to the genetic difference between the two cultivar which were the only different factor for the experiment. Post hoc testing was carried out using Duncan Multiple Range Test (DMRT) to separate the significance means at the 0.05 confidence limit (alpha level) for the mean.

11. Result

11.1. Shoot Height

The shoot height of the two varieties increased gradually from the beginning of the experiment to the end (figure 1). At the end of the experiment, the shoot height of the Roma (hybrid) was higher than that of the local tomato. The result of the ANOVA shows that there was no significant difference (P>0.05) between the shoot height of plants in the two cultivars.

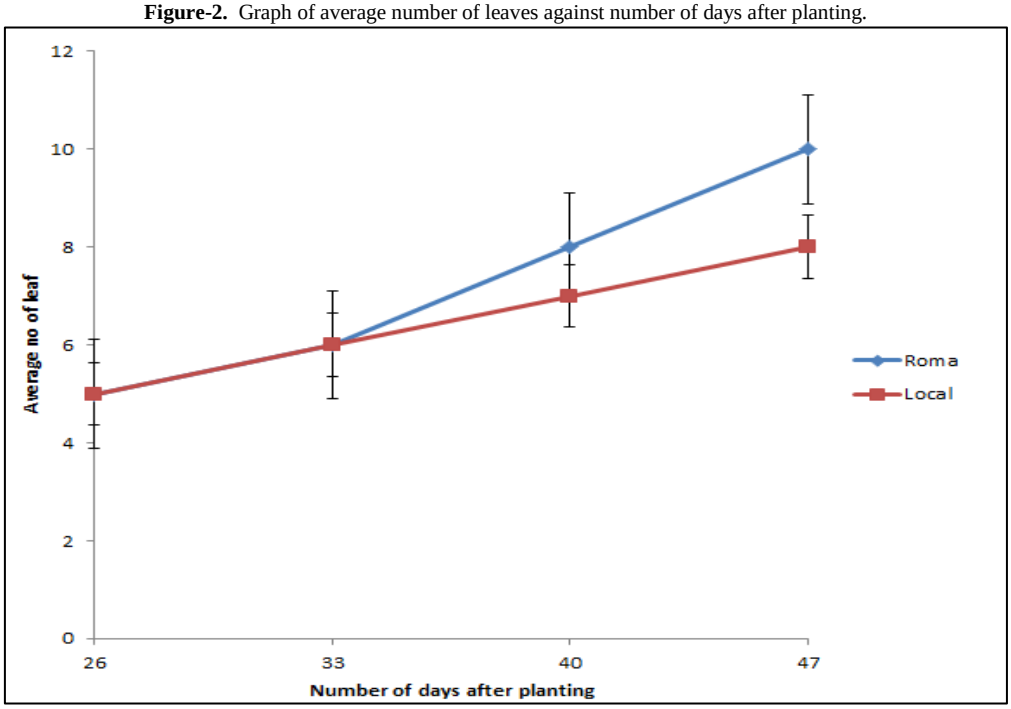
Figure-1. Graph of average shoot height against number of days after planting.



11.2. Number of Leaves

Both Roma and local tomatoes were observed to have similar number of leaves from the beginning of the experiment till the 33rd day after which that of Roma increased gradually while that of local tomato fell below it and did not recover till the end of the experiment. (Figure 2) The result of the ANOVA shows that there was significant difference ($P<0.05$) between the average number leaves of the two cultivars.

Figure-2. Graph of average number of leaves against number of days after planting.



11.3. Fresh and Dry Weight

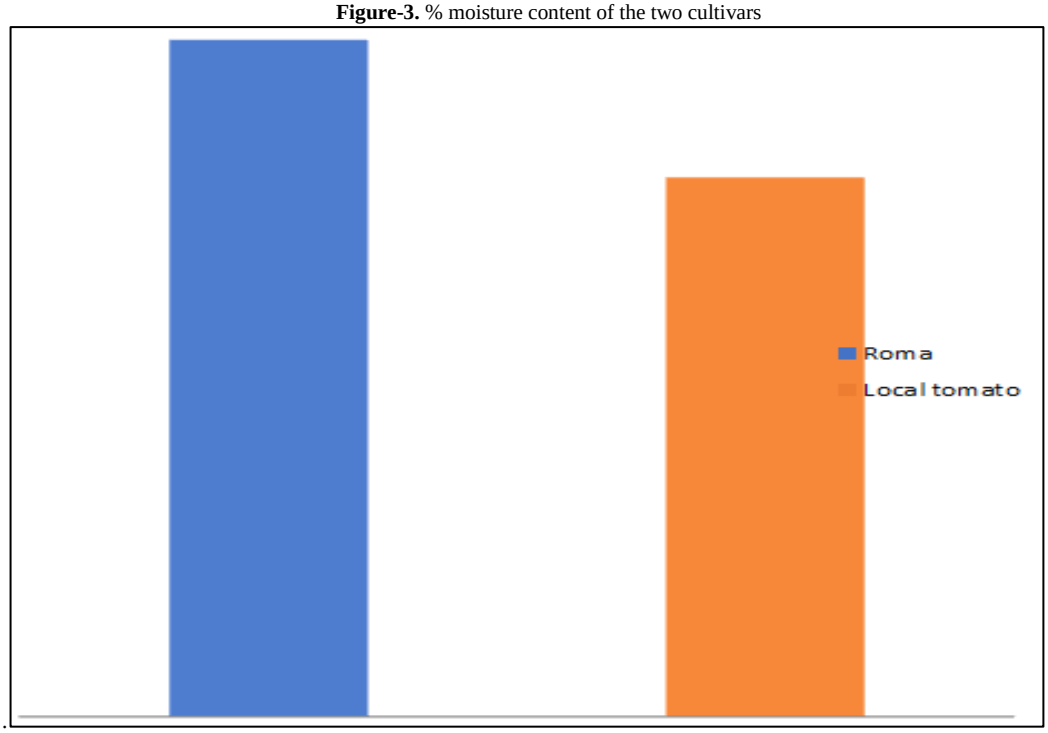
The percentage moisture content for the fruit is shown in the table below.

Table-2.

Cultivar	Roma	Local tomato
% moisture content	5.9	4.7

The result of the ANOVA shows that there is significant difference ($P<0.05$) between the fresh and the dry weight of the fruit in the two different cultivars. The same result was obtained for the whole shoot of the plant in the two cultivars.

Figure-3. % moisture content of the two cultivars



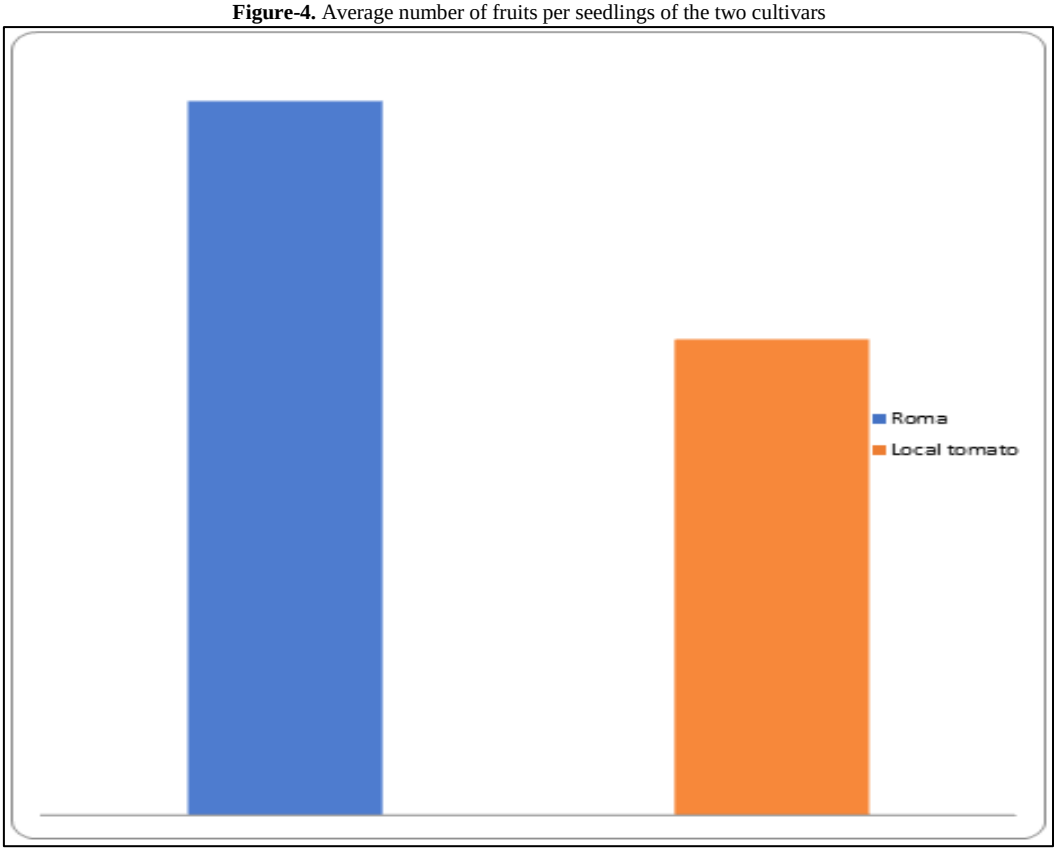
11.4. Number of Fruits

The numbers of fruits produced in the plants in the two cultivars increase with time as a greater number of fruits were obtained in the Roma compareto the local tomato. The result of the ANOVA showsthat there is no significant difference (P>0.05) between the number of fruits in the two cultivars.

Table-3.

Cultivar	Roma	Local tomato
Average number of fruits per seedling	15	10

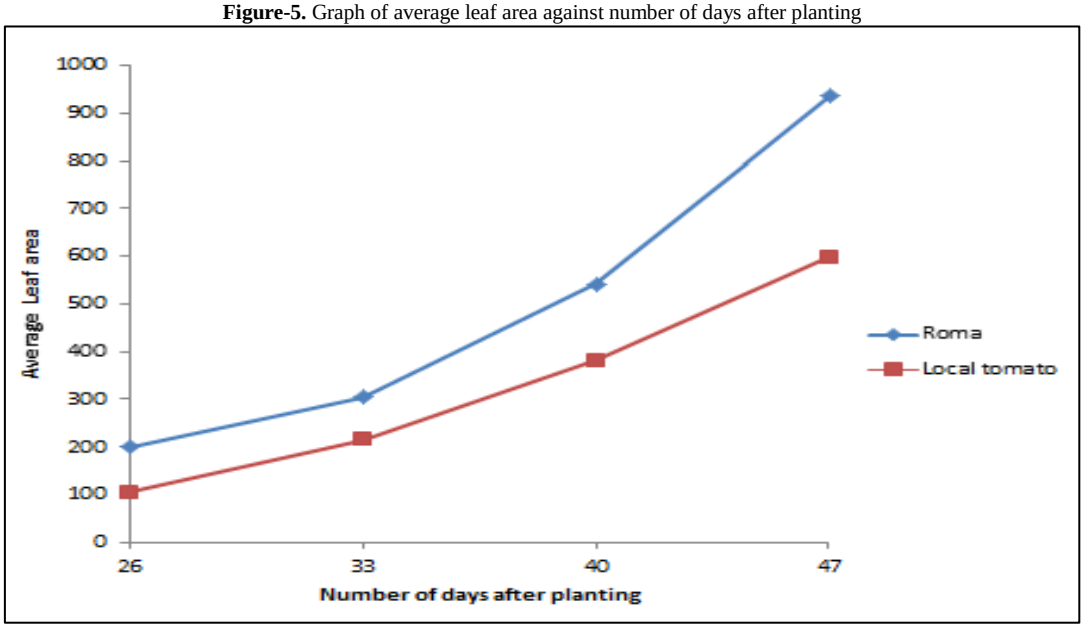
Figure-4. Average number of fruits per seedlings of the two cultivars



11.5. Leaf Area

There was a gradual increase in the leaf area of the plants in the two varieties from the beginning to the end of the experiment. At the end of the experiment, the Roma has the highest average leaf area compare to the local tomato. The result of the ANOVA showed that there is significant difference (P<0.05) between the leaf areas of the two cultivars. From the graph, it can be observed that the leaf area followed similar trend from the beginning of the experiment till the end of the experiment but the Roma was higher than the local throughout the experiment.

Figure-5. Graph of average leaf area against number of days after planting



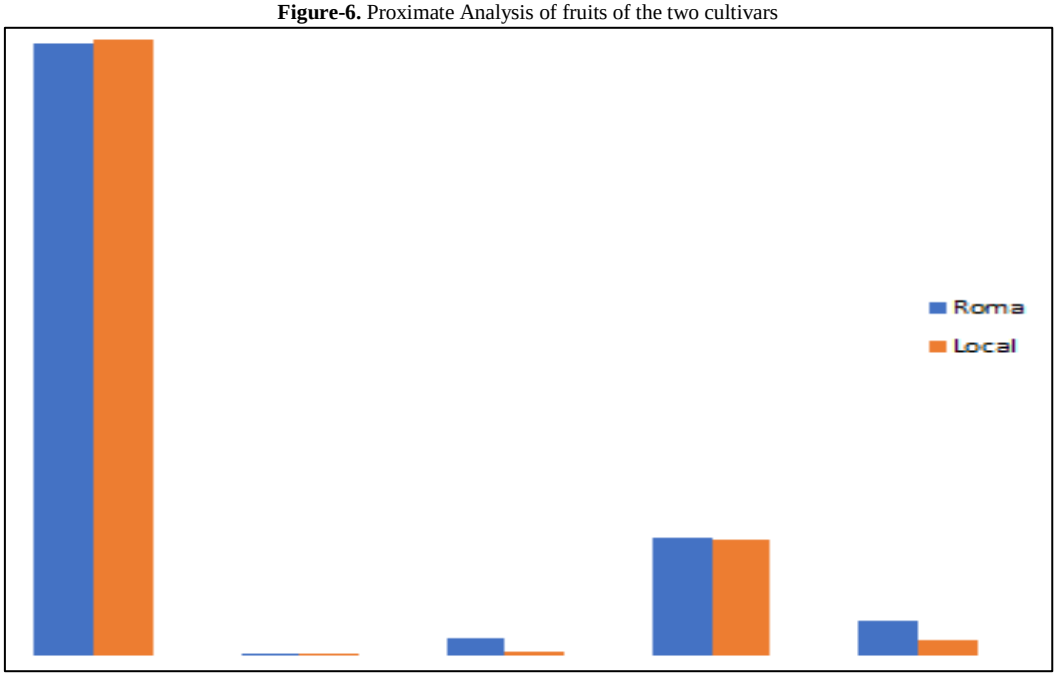
11.6. Physical Properties

The shape of the fruits varied from spherical to pear-like. The result of the ANOVA shows that there is a significant difference ($P<0.05$) in both the longitudinal (stem to blossom end) and cross-sectional (transverse diameter) dimensions of the two cultivars.

12. Proximate Analysis (Nutritive Value) Studies

Proximate analysis of the fruit revealed that the Roma have a higher percentage of the nutritive value compare to the local tomato fruits.

Figure-6. Proximate Analysis of fruits of the two cultivars



13. Discussion and Conclusion

In the present study of comparing two tomato cultivars (*Lycopersicum esculentum*), all the natural conditions that are necessary for the normal growth and development of the tomato seedlings were maintained. These environmental conditions were the same for all the seedlings throughout the experimental period. It can thus be inferred that any differences noticed during the course of this experiment would be as a result of the difference that result from the internal factors (e.g. genetic make-up) of the different cultivars.

The Roma-VF has the highest longitudinal and cross-sectional diameter. This result does not agree with that of Viswanathan, *et al.* [7] that the diameter along the cross-section is mostly greater than the longitudinal diameter. Rather, it agrees with the observation of Atherton and Rudich [8] that tomato cultivars differs greatly in fruit shape and may be spherical, oblate, elongated or pear-like.

The Roma varieties were better adapted to the environment than the local tomato. The Roma still remained green under exposure to unfavorable condition such as water scarcity whereas, the local tomato seedlings under the same condition began to lose the green colour of its leaves. In addition, higher shoot height as well as average numbers of leaves per seedling were recorded in the Roma VF in comparison to the local tomato. This is in agreement with Calvin [9] that fresh Roma tomatoes (also known as plum tomatoes) grew rapidly in the 1990s.

This may be due to the fact that hybrid tomatoes are tomato plants that have been bred for specific reason–to be disease resistant, to grow larger tomatoes etc. Hybrids often produce higher yield of fruits, mature earlier, have a more uniform appearance and a higher fruit quality. Thus, the Roma varieties were able to adapt to harsh conditions. This result agrees with that of Moore-Sweetney that; heirloom tomatoes were not as productive as the hybrid plant. Hybrid tomatoes are favored over other tomatoes because they are disease resistant.

Proximate analysis of the fruit revealed that in all the nutritive parameters considered, the hybrid Roma VF, had higher percentage than the local tomato e.g. the crude fiber content of the Roma is higher than that of the local tomato. Also, the percentage crude protein of Roma is higher than that of the local tomato except the percentage moisture content of local tomato which is higher than that of roma tomato showing that the fruits of the local tomato is more juicy than the fruits of the roma tomato, This is in agreement with the work of Arlene Wright Correll [10], that the greatest sauce was prepared from Roma variety of all the tomato varieties;thereforewhen growing tomato for the purpose of household consumption,Roma is better than local tomato.The best salsa is made with a meaty fruit that's not too juicy but has a rich flavor. The rich flavor and low moisture flesh of these meaty fruits are ideal for salsa recipes [11]. This result also agree with Lewis Grizzard, that Plum tomatoes which include Roma have thick walls and fewer seeds than the other tomato categories, making them excellent choices for tomato-based sauces.

The internal factors within plants (genetic factors) contribute greatly to the growth and development of the plant despite the fact that the plants are affected by various environmental factors. This result is supported by Trinklein

and Lambeth [12] that the firmness of the pericarp tissue of tomato was control by a single recessive gene. Yield potential is determined by genes of the plant. A large part of the increase in yield over the years has been due to hybrids and improved varieties. Other characteristics such as quality, disease resistance, drought hardiness are determined by the genetic make-up. Corn hybrids are example of a dramatic yield increase resulting from genetics. (Dr. Steve Broome NC State University) The Roma tomato makes the greatest sauce.

Recommendation

The Roma is more adapted and yield better than the local tomato and is so recommended for plantation especially for commercial purposes.

This work also show that Roma tomato plant has a lot of advantages compare to local tomato, Roma tomatoes are small enough to be grown in a Topsy-Turvy planter and are typically used for making pastes sauces and salads. The Roma tomatoes work for making sauces and typically have a low acid content. The Topsy-Turvey tomato planter is a small planter that grows tomato plants upside down; regular tomato varieties typically will be too heavy for this type of growth pattern. Small fruited varieties of tomatoes work best with the Topsy-Turvy.

The ability of roma to adapt to the environment better is as a result of hybrid vigor or we call it the advantage of crossing over. The plant also set all their fruit within a relatively short period of time. However despite all the works that have been done so far on these cultivars, little is known about the Topsy-Turvy.

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Appendix

Analysis of variance (ANOVA) Result for average leaf area

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	58482.000	1	58482.000	.763	.416
Within Groups	459869.500	6	76644.917		
Total	518351.500	7			

Analysis of Variance (ANOVA) Result of shoot height

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	78.125	1	78.125	1.088	.337
Within Groups	430.750	6	71.792		
Total	508.875	7			

Analysis of Variance (ANOVA) Result of Average no of leaf

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	43365.125	1	43365.125	.983	.360
Within Groups	264643.750	6	44107.292		
	308008.875	7			

Physical properties

Physical property	Roma-VF	Local type
Fruit length (stem→blossom; cm)	4.76d	2.67b
Fruit length (transverse; cm)	4.67c	3.27b

Nutritive value analysis

Plant type	Percentage Moisture	Percentage Ash	Percentage Crude fibre	Percentage Ether Extract	Percentage Crude Protein
Roma	93.16	0.39	2.73	18.03	5.25
Local	93.66	0.37	0.69	17.72	2.41