

EVALUATION OF FIVE STAKED TOMATO (*Lycopersicon esculentum* Mill.) VARIETIES FOR QUALITY AND YIELD

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May 2013

ABSTRACT

A field experiment was conducted at the Gladstone Road Agricultural Centre from November 2012 to February 2013. This study evaluated five tomato varieties: 'BHN 543', 'Finishline', 'Rocky Top', 'Soraya' and 'Yellow Jubilee'. The trial was set out in a completely randomised design with three replications. The tomato varieties all matured within range of the expected number of days to maturity from transplanted seedlings. All five of the tomato varieties showed symptoms of the tomato yellow leaf curl virus (TYLCV), while the catface disorder was manifested only in 'BHN 543', 'Rocky Top' and 'Soraya'. Significant differences were observed between the five varieties for the total number of fruit per plant, the total weight of fruit per plant, the weight of a single fruit, the weight of marketable fruit per plant and the number of marketable fruit per plant. The variety producing the largest number of fruit per plant was 'Soraya'. The potential yields for the tomato varieties ranged from 4.2 tonnes/hectare for 'Yellow Jubilee' to 18.6 tonnes/hectare for 'Soraya'.



Tomato variety 'Rocky Top' grown on stakes at the Gladstone Road Agricultural Centre during 2013

Introduction:

The tomato (*Lycopersicon esculentum* Mill.) is undoubtedly the most important vegetable grown in the world, where it is cultivated in both tropical and temperate zones. The general popularity and health benefits associated with this vegetable crop make it one of the most commercially viable of all agricultural commodities. Cultivation of this high yielding, short duration crop is increasing worldwide. According to recent FAO statistics approximately 160 million tonnes are produced annually on 4.7 million hectares (FAOSTAT, 2011). Tomato production in the Caribbean region is estimated by FAO to be around 960 thousand tonnes per annum, with The Bahamas producing 4,434 tonnes, or about 0.5 percent of that total.

Tomatoes are consumed fresh, cooked or processed into various products. In The Bahamas, it is an important ingredient in the daily diet of Bahamians throughout the islands and is perhaps the most commonly used vegetable. The tomato is composed mainly of water (approximately 90%), soluble and insoluble solids (5-7%), citric and other organic acids, and vitamins and minerals (Pedro and Ferreira, 2007). Ripe tomatoes have a high content of the antioxidant lycopene, which plays a possible role in the prevention of certain forms of cancer (Agarwal and Rao, 2000; Radzevičius *et al.*, 2009). Another important antioxidant is carotene (Radzevičius *et al.*, 2009), also noted for its cancer prevention properties.



Staked tomato vines at the Gladstone Road Agricultural Centre

Tomatoes thrive best in moderate climates, but can adapt to a wide range of climatic conditions. They can be grown in a variety of soil types, but do best on well-drained, fertile soils. They can be cultivated in the open under field conditions or in a greenhouse under environmentally controlled conditions. Tomatoes are usually staked and supported off the ground, in an effort to minimise losses from rots when the fruit is in contact with the soil. This practice has also proven to be effective in reducing the incidence of pest problems, thereby increasing yields (Saunyama and Knapp, 2003).

Tomato plants may be classified into three general types, according to their growth habits: determinate, indeterminate or semi-determinate. Determinate varieties are bred to grow into a

compact shrub or ‘bush’ of approximately four feet in height which stops growing when fruit sets at the terminal bud. The determinate tomato plant produces all of its fruit at around the same time, and then dies back after a short season. Indeterminate tomatoes are the ‘vine’ types and grow to more than ten feet in length. Flowers and fruit are found in varying stages of development throughout the growing season. Indeterminate varieties continue to produce fruit until the plant dies. Most of the heirloom tomatoes are indeterminate. Semi-determinate varieties are somewhere in between determinate and indeterminate, having characteristics of both types. They produce all their fruit at once like the determinate varieties, but produce a second crop of tomatoes after the first crop. Very few tomato varieties are of this type.

The tomato is a highly perishable crop and cannot be stored for extended periods. The internal structure (Plate 1) of the tomato varies from fruit to fruit and plays an important role in qualities such as uniformity of shape, size and firmness (Li *et al.*, 2010; Gastélum-Barrios, *et al.*, 2011). Firmness is a quality consideration that impacts storability and shelf life of the fruit (Wu and Abbott, 2002) and is strongly affected by cultivar, environment, nutrition and physiological disorders (Davies and Hobson, 1981).

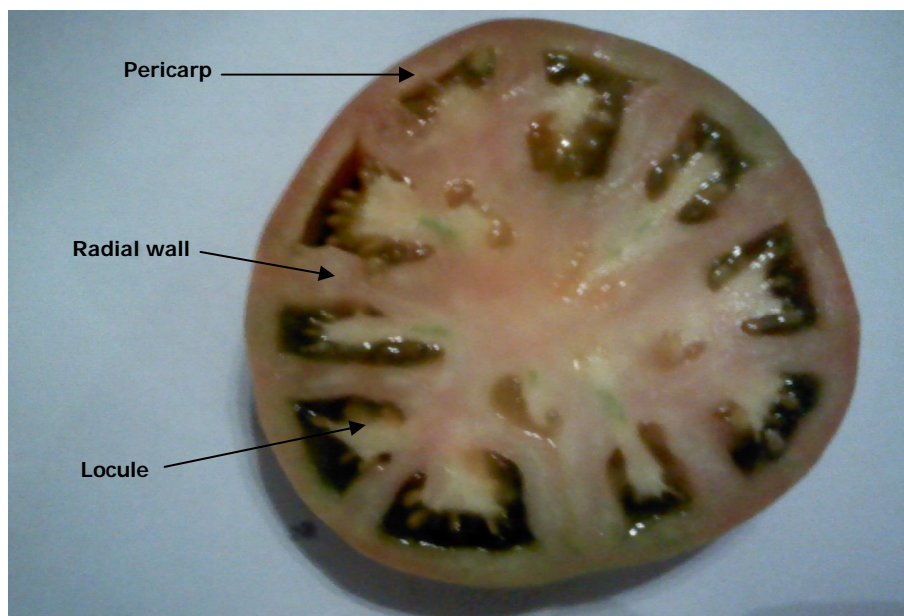


Plate 1. Sliced ‘Finishline’ tomato variety showing internal structures.

The texture of the flesh itself, which includes the radial wall, locular cavities and the outer pericarp, affects the quality of the fruit (Wu and Abbott, 2002). The pericarp is the outer wall of the fruit that gives it form (Plate 1). According to Kumari and Sharma (2011), pericarp thickness is an important feature of the tomato fruit, as varieties with thicker pericarp are better able to withstand travel over long distances and remain firm for a longer period, when compared to thinly fleshed tomatoes. Pericarp thickness is also related to fruit size, according to Stevens *et al.* (1977), who observed that large fruit had thicker pericarp than small fruit.

The radial wall (Plate 1) separates the locular cavities, or locules. Most tomato varieties have between three and eight locules filled with seeds and gelatinous material (Li *et al.*, 2011). Fruit

with a higher locule number tend to be firmer. In an early study by Yeager (1937), a link was established between the number of locules and fruit shape and size. Locule number and fruit size in tomatoes are closely related to malformation (Liu and Li, 2012). The greater the number of locules, the larger is the fruit, resulting in more incidences of malformation (Wien and Turner, 1994; Liu and Li, 2012). This malformation in tomato, commonly referred to as catfacing, is characterised by an abnormally large blossom-end scar (Wien and Zhang, 1991). According to Barten *et al.* (1992), catfacing occurs when tomato plants are exposed to low temperatures during flowering and can result in a severe reduction in yields.

An understanding of the internal structure and textural properties of the tomato fruit is important to the market acceptability of this product. These characteristics are helpful for estimating the quality of the tomato fruit, so that the proper handling, packaging and storage conditions can be determined (Li *et al.*, 2011). There is much variation in the different internal structures and textures of the tomato fruit, since they always have different locular cavities, though grown from the same plant (Li *et al.*, 2010). By selecting the appropriate varieties for their cropping systems, local farmers will ensure that they bring to market a high quality tomato product that the consumer would like.

There is a growing trend among Bahamian consumers for locally produced fresh fruits and vegetables. The production of tomatoes, however, is plagued with many difficulties. Due to these challenges, which include adverse climatic conditions, poor soils, lack of improved varieties and poor agronomic practices, the demand for an adequate supply of fresh market tomatoes is rarely satisfied. Bahamian farmers are thus faced with the challenge of providing excellent quality tomato produce for the local market. In an effort to provide the latest information on tomato varieties suitable for the growing conditions of The Bahamas, a variety trial was conducted at the Gladstone Road Agricultural Centre during the vegetable growing season of 2012-2013.

Objective:

The purpose of this study was to evaluate the quality and yield of five tomato varieties under local growing conditions, in order to make recommendations to local Bahamian farmers on the most suitable of them.

Materials and Methods:

The variety trial was conducted at the Gladstone Road Agricultural Centre from November 2012 to February 2013. The five varieties were 'BHN 543', 'Finishline', 'Rocky Top', 'Soraya' and 'Yellow Jubilee'. The varieties 'BHN 543', 'Finishline', 'Rocky Top' and 'Soraya' are products of the Seedway Seed Company, while the 'Yellow Jubilee' tomato is a medium to large-sized heirloom variety. Four of the varieties, 'BHN 543', 'Finishline', 'Rocky Top' and 'Soraya' have been bred as determinate cultivars, while the open-pollinated variety 'Yellow Jubilee' is of the indeterminate type.

The experiment was set out in a completely randomised design with three replications. Each replicated plot consisted of ten plants. Inter-row spacing was 1.5 m (5.0 ft), while within row

spacing was 60 cm (2 ft) between plants. The five varieties were grown in single row ridged plots under drip irrigation, which supplied water throughout the experimental period. Plants were tied to 1.0 m length stakes, placed at the side of each plant approximately one month after transplanting. Each plant was pruned by removing the lateral branches to retain a single stem and allowing it to climb along the stake support. The usual cultural practices were observed to ensure that an even stand of plants was maintained in the field plots. The plants were not treated with insecticides or fungicides, in order to determine their resistance or susceptibility to insect pests and diseases.

Tomatoes were harvested during February, upon reaching maturity. A total of 15 plants per variety, five plants for each of the three replicated plots, were sampled. Fruit displaying surface defects, uneven ripening, disease or insect damage were discarded. The harvested tomatoes were then graded as marketable or unmarketable quality tomatoes, according to their size and appearance. For this study, all observations and measurements were made on the initial harvest of tomatoes.



Staked tomatoes at the Gladstone Road Agricultural Centre

The mean daily maximum and minimum temperatures for the trial period were 27.1°C (80.8°F) and 19.9°C (67.7°F), respectively. The total rainfall for the period was 141.46 mm (5.57 in). Mean monthly sunshine duration for the period was 8.0 h. Weather information (Table 1) was obtained from the Meteorological Department of The Bahamas.

Table 1. Weather data on rainfall, hours of sunshine and mean maximum and minimum temperatures for New Providence for the period of November 2012 to February 2013, courtesy of the Meteorological Department of The Bahamas.

Month	Total rainfall (mm/inches)	Mean monthly radiation (h)	Mean maximum temperature (°C/°F)	Mean minimum temperature (°C/°F)
November 2012	24.9/0.98	8.1	26.9/80.5	19.8/67.7
December 2012	58.9/2.32	7.6	26.9/80.5	19.8/67.7
January 2013	6.86/0.27	7.6	27.2/81.0	20.2/68.4
February 2013	50.8/2.0	8.7	27.2/81.0	19.6/67.2

Note: Monthly mean values have been rounded up to the nearest tenth.

Statistical Analyses:

All experimental results were analysed using Instat+™ v3.36 and ASSISTAT. Instat is an interactive statistical package, copyright © 2006, Statistical Services Centre, University of Reading, UK. All rights reserved. ASSISTAT, Version 7.6 beta (2013), website – <http://www.assistat.com>, by Fransisco de Assis Santos e Silva, Federal University of Campina-Grande City, Campina Grande, Brazil.

Results:

Results were based on a single harvest of the tomato varieties. Significant differences were observed between the five varieties, as revealed by the analysis of variance (Table 2). The varieties had a significant effect on the total number of fruit per plant, the total weight of fruit per plant, the weight of a single fruit, the number of marketable fruit per plant and the weight of marketable fruit per plant.

Table 2. Analysis of variance (ANOVA) for total number of fruit per plant, total weight of fruit per plant, weight of a single fruit, number of marketable fruit per plant and weight of marketable fruit per plant for five tomato varieties. Standard error is for each treatment mean. Error mean square has 74 df. *, ** and *** denote statistical significance at 5, 1 and 0.1% level of confidence, respectively. NS indicates differences between means not significant.

-----Significance levels-----						
Source	Df	Total number of fruit per plant	Total weight of fruit per plant (g)	Weight of a single fruit (g)	Number of marketable fruit per plant	Weight of marketable fruit per plant (g)
Varieties	4	**	**	**	**	**
Error	70					
Std. Err		0.3	78.9	6.5	0.4	81.9

Mean values for the total number of fruit per plant, total weight of fruit per plant, weight of a single tomato, number of marketable fruit per plant and weight of marketable fruit per plant for the five varieties are shown in Table 3. Total fruit weights per plant ranged from 0.6 kg per plant for ‘Yellow Jubilee’ to 2.1 kg per plant for ‘Soraya’, in agreement with Meseret *et al.* (2012) whose results varied between 1.1 and 1.7 kg for both improved cultivars and heirloom tomato varieties.

Table 3. Mean values of yield responses for five tomato varieties assessed during February, 2013

Variety	Total number of fruit per plant	Total weight of fruit per plant (g)	Weight of a single fruit (g)	Number of marketable fruit per plant	Weight of marketable fruit per plant (g)
BHN 543	3.7c	724.2cd	194.6b	3.1c	617.4c
Finishline	4.0c	913.8c	234.0a	3.2c	719.7c
Rocky Top	5.5b	1330.3b	233.0a	5.1b	1205.8b
Soraya	10.7a	2098.6a	200.0b	10.1a	2005.6a
Yellow Jubilee	4.5bc	604.2d	135.0c	3.4c	449.1c

The t-test at a level of 5% probability was applied. For each variety, means within columns bearing different lowercase letters differ significantly at 5% level of confidence.

Of the five tomato varieties, ‘Soraya’ also had the highest marketable fruit weights per plant and the largest number of marketable fruit per plant. The remaining four varieties averaged less than half that number. This difference is most likely due to a higher percentage of fruit set by ‘Soraya’. The variety ‘Rocky Top’ proved to be the second best performer, with 1.2 kg of marketable tomato

fruit per plant. The varieties ‘BHN 543’, ‘Finishline’ and ‘Yellow Jubilee’ appeared to be very similar in yield capacity, showing the lowest yields of the five tomato varieties. The varieties ‘Finishline’ and ‘Rocky Top’ yielded the largest weights for a single tomato fruit, followed by ‘Soraya’ and ‘BHN 543’. The variety ‘Yellow Jubilee’ had means within the lower range of values for all the categories evaluated.

Based on the results in Table 3 for the total yields per plant and marketable yields per plant, losses due to unmarketable quality tomatoes were lower in ‘Soraya’ (4.4%), ‘Rocky Top’ (9.4%), and ‘BHN 543’ (15%), while ‘Finishline’ and ‘Yellow Jubilee’ suffered the highest number of losses for unmarketable tomato fruit at 21% and 26%, respectively.

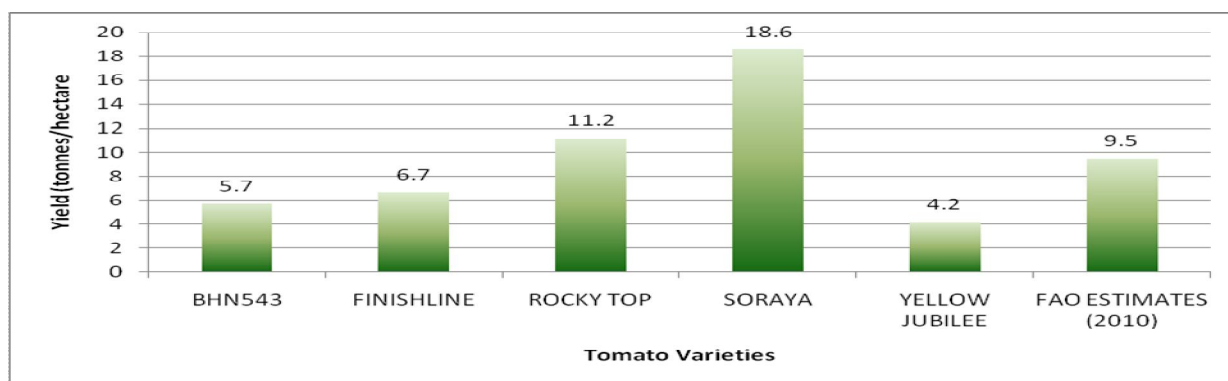


Fig. 1. Potential yields of five tomato varieties evaluated at the Gladstone Road Agricultural Centre during 2013. FAO yield estimates for The Bahamas in 2010 are found in the column at far right.

Results, on a tonnes per hectare basis, were extrapolated from the mean weights expressed as g per plant and are displayed graphically (Figure 1). The potential yields for tomato ranged from 4.2 to 18.6 tonnes per hectare for the tomato plants, with the variety ‘Soraya’ presenting the highest mean yields of marketable fruit. The potential yields for two of the five varieties compared favourably to FAO yield estimates for The Bahamas for 2010.

Table 4. Quality characteristics of five tomato varieties evaluated at the Gladstone Road Agricultural Centre during 2013.

Variety	Stated number of days to maturity from transplanted seedlings	Actual number of days to maturity from transplanted seedlings	Fruit size	General appearance	Fruit shape	Flesh and skin colour	Visible signs of disease or disorder
BHN 543	72	82	Large to extra large fruit	Well formed, smooth, clean	Flattened globe	Red flesh and red skin	Catfacing, TYLCV
Finishline	69-80	82	Large to extra large fruit	Well formed, smooth, clean	Globe	Red flesh and red skin	TYLCV
Rocky Top	74	82	Large to extra large fruit	Well formed, smooth, clean	Globe	Red flesh and red skin	Catfacing, TYLCV
Soraya	69-80	82	Large to extra large fruit	Well formed, smooth, clean	Globe	Red flesh and red skin	Catfacing, TYLCV
Yellow Jubilee	80	82	Medium to large fruit	Well formed, smooth, clean	Flattened globe	Golden yellow flesh and skin	TYLCV

The five tomato varieties in this study exhibited acceptable post-harvest quality characteristics (Table 4), consistent with the basic requirements for the USDA standards for grades of fresh

tomatoes (USDA-AMS, 1997). The tomatoes were medium to large in size, generally well formed and free of defects, except for the catfacing disorder which was seen in small numbers on the fruit of the varieties 'BHN 543' and 'Rocky Top', and in even greater numbers on the variety 'Soraya'. No manifestation of the catface disorder occurred in the tomato varieties 'Finishline' and 'Yellow Jubilee'. Evidence of the tomato yellow leaf curl virus (TYLCV) was observed in the field plots and affected all varieties. The actual number of days to maturity for the five varieties was between two and ten days longer than the stated number of days to maturity.

Plates 3 and 4 give some indications of the problems encountered in the field with the cultivation of the tomato crop. The experimental plots were relatively free of problems, with the exception of the catfacing disorder, most prevalent in the tomato variety 'Soraya', and the tomato yellow leaf curl virus (TYLCV), which affected all five varieties.

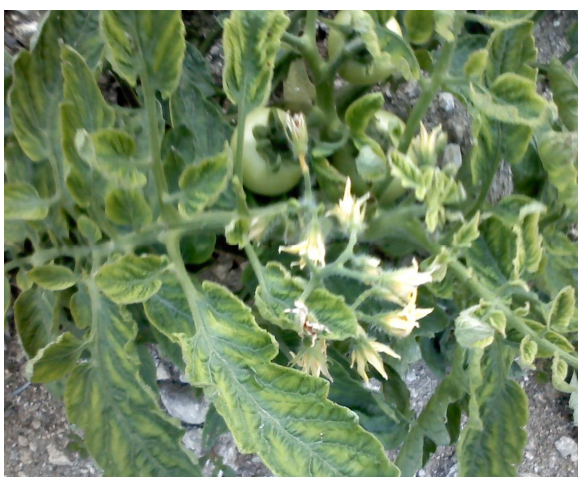


Plate 3. TYLCV with yellowing and curling of leaf

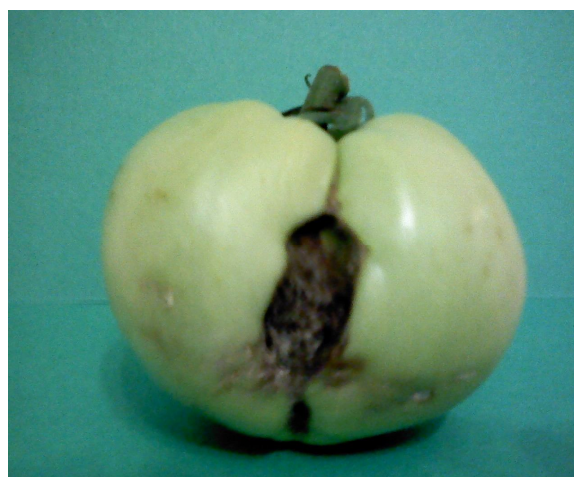


Plate 4. Characteristic catfacing on immature tomato

Tomato plants infected by the tomato yellow leaf curl virus (Plate 3) exhibit symptoms such as a reduction in leaf size, the curling upward of leaves, severe stunting and the interveinal chlorosis of leaves (Martinez-Culebras *et al.*, 2001; Salati *et al.*, 2002). None of the five tomato varieties showed resistance to the tomato yellow leaf curl virus. The tomato yellow leaf curl virus is not transmitted from plant to plant by handling, but is spread from infected solanaceous weed species to cultivated tomato plants by whiteflies (Ajlan, *et al.*, 2006; Al-Ani, *et al.*, 2011). Increased whitefly populations are associated with the tomato yellow leaf curl virus. This insect vector is controlled by limiting its numbers. Agronomic practices, such as weeding, the removal of vegetative matter and periodic spraying with insecticides are measures used to prevent the spread of the virus.

Catfacing (Plate 4) is a distortion that appears as a scarring and malformation at the blossom end of the tomato fruit, rendering it unmarketable (Stevenson and Heimann, 1981). It is found most commonly in the first fruit harvested (Masarirambi, *et al.* 2009) and is more prevalent in large to extra large fresh-market tomatoes. There are some tomato varieties that appear to be less susceptible than others to the catfacing disorder. Barten *et al.* (1992) found that low temperatures induced catfacing of tomato fruit during flower development. It has been suggested that the low temperatures inhibit pollination of the flower and also cause the blossom to stick to the fruit.

For each of the five tomato varieties, five fruit were selected at random and allowed to ripen. These were then sliced horizontally, in order to determine the number of locules within their internal structures (Table 5). The varieties ‘Finishline’, ‘Rocky Top’ and ‘Soraya’ had the highest number of locules, followed by ‘BHN 543’ and ‘Yellow Jubilee’, which had the lowest count.

Table 5. Number of locules for the five tomato varieties.

Variety	BHN 543	Finishline	Rocky Top	Soraya	Yellow Jubilee
Number of locules per fruit	7.6	8.8	8.6	8.2	6.4

These figures represent the means of five fruit, determined by counting.

Variations in the locular cavities of the five tomato varieties are shown in Plate 5(a-e). The locular cavities are important to the firmness of the tomato fruit and protect it from mechanical damage (Li *et al.*, 2010). Locules should be filled with gel and not air spaces, as noted in the variety ‘Yellow Jubilee’ at bottom (5e). These air spaces, or hollow areas, in the tomato fruit are not acceptable to consumers and do not transport well because of their relative softness (Masarirambi, *et al.* 2009). Note also the areas of white tissue of the radial walls of a few of the sliced tomatoes, in particular the variety ‘Soraya’ at 5d. No symptom of this internal white tissue is apparent until the tomato fruit is sliced. This problem occurs under extreme conditions and is reduced with the application of potassium fertiliser (Masarirambi, *et al.* 2009). Fruit malformation affects not only the appearance of the tomato, but affects also the quality and value on the market (Li *et al.*, 2007).

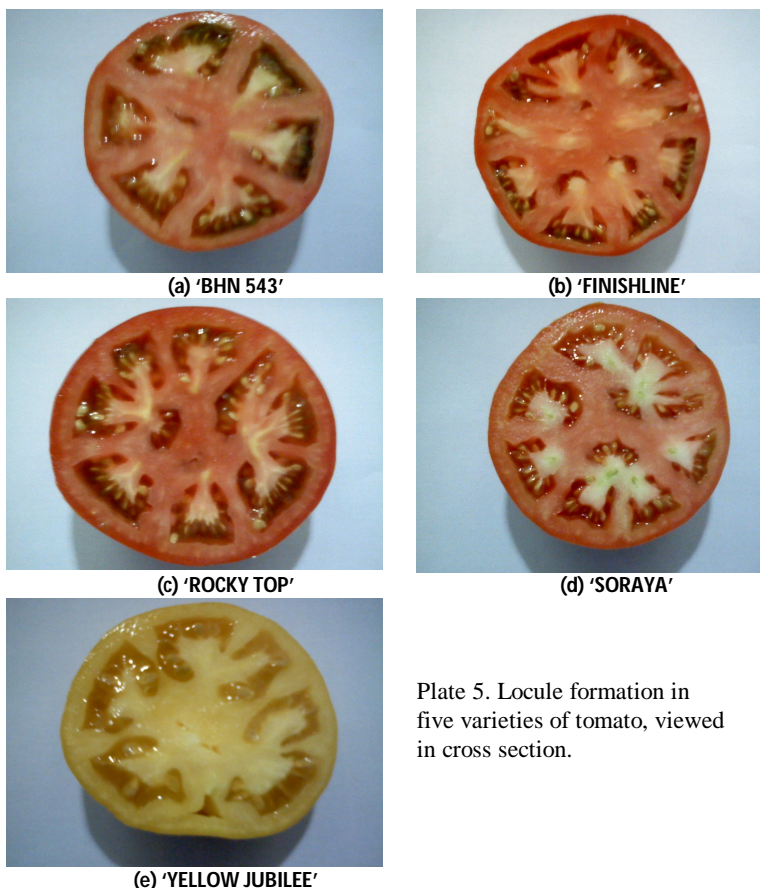


Plate 5. Locule formation in five varieties of tomato, viewed in cross section.

Discussion:

The five tomato varieties all matured within range of the expected number of days to maturity from transplanted seedlings. While the varieties in this study matured somewhere between 70 and 80 days after transplanting, there are some tomato varieties that mature as early as 45 days after transplanting. Most varieties mature somewhere between 45 and 90 days. The days to maturity in tomato is attributed to variety, but is also influenced by environmental factors, such as temperature, and growing conditions.

The overall results of the yield performance for the varieties in this study were well below the average productivity of tomato reported by Meseret *et al.* (2012), who found variations in the performance of tomato cultivars and heirloom varieties under tropical conditions. Their results indicated that the hybrid varieties all produced higher yields than the heirloom varieties. Under subtropical conditions, Zahedi and Ansari (2012) found significant variation in yield of tomato genotypes and attributed it to seasonal variability, whose impact on plant growth and yield was different for different genotypes. The relatively low yields in this study compared favourably with yields reported by Olaniyi *et al.* (2010), who reported yields of less than 20 tonnes per hectare for tomatoes growing in the tropical zones.

The variety ‘Soraya’ gave the largest number of marketable fruit per plant, the highest weight of marketable fruit per plant and the highest potential yield in tonnes per hectare. This suggests that this variety is better able to tolerate the adverse environmental growing conditions, disease and insect challenges and other yield constraints encountered during the growing period than any of the other four varieties evaluated in this study.

Compared to a previous study (Richardson, 2012), ‘BHN 543’ and ‘Finishline’ gave virtually the same results as in this present study, while ‘Rocky Top’ and ‘Soraya’ saw significant improvements in their potential yields. The heirloom variety ‘Yellow Jubilee’ was not evaluated in the 2012 study. The increase in number of fruit and yield per plant for ‘Rocky Top’ and ‘Soraya’ could be the result of more favourable temperatures during this season. The previous season saw low temperatures during flower development, which resulted in catfacing in one of the tomato varieties under evaluation. Though temperatures this season were not as low during flower initiation, there was a higher incidence of catfacing, this time in three of the varieties being evaluated.

There was a range of variability in the number of locules found among the five tomato varieties in this study. The number of locules also varied within each variety. There appeared to be some relationship between the number of locules found in each variety and the weights of a single fruit, as the heavier fruits all contained a larger number of locules. This corroborates the research of Muños *et al.*, (2011) who demonstrated that the increase in fruit weight was the result of the increase in the number of locules per fruit. In addition, Wien and Turner (1994) proposed that the increased weight of catfaced fruit found in their study on blossom-end scarring in tomato may have been the result of an increased number of locules per fruit. Although the variety ‘Soraya’ performed well above all other varieties, the catfacing disorder contributed to a reduction in marketable quality fruit. This was also so for the variety ‘BHN 543’. ‘Yellow Jubilee’ had a lower

number of locules with no catfacing, but yielded the lowest weight for a single fruit, and consequently the lowest yield of marketable tomato fruit per plant.

Based on the findings of this research paper, the varieties 'Rocky Top' and 'Soraya' are the most promising with respect to their yields and quality characteristics. Of the five tomato varieties, the potential yield was very high for 'Soraya'. The results of this experiment support the previous experiment which evaluated the performance of four of these tomato varieties. The varieties used in this study may be considered for further examination and recommendation to local farmers. With proper management practices, including preventative measures to prevent the spread of the tomato yellow leaf curl virus (TYLCV) by whiteflies, a successful crop can be obtained by local farmers. Further studies are required in order to make a more detailed assessment of the internal structure of the tomato and its effects on post-harvest quality characteristics.



Staked tomatoes ripening on the vine, grown at the Gladstone Road Agricultural Centre during 2013

Acknowledgements:

Much appreciation is extended to Jetta Rolle, Geareace Gordon and Valdarene Daxon of the Crops Section at the Gladstone Road Agricultural Centre for their assistance and cooperation in the planting, managing and harvesting of field plots, and the collection of data for this trial.

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