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Articles



Improving the Production of Tomatoes through Agronomic Research to Improve Food Security in Barbados.

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Abstract

Barbados food import bill has been rising steadily over the last 10 years by 20.4% and is expected to continue to rise due to the volatility and increasing food prices of agricultural commodities on the international market. This growing increase of 20.4% has highlighted the need for the country to start producing more of the foods which can be grown locally which are currently being imported, to help reduce this growing trend. With one of the country's natural resources (land) being reduced annually, poor crop yields and low use of improved crop varieties, agricultural production has been severely disadvantaged resulting in the island's food security being drastically compromised. The government aware of the gravity of this situation has committed itself to provide safe, adequate, nutritious and affordable food to its people and is relying upon the Agriculture Sector to help in this effort. The Ministry of Agriculture has taken the initiative and has focused its attention on the tomato sector embarking on an intensive research program to select varieties amenable to the fresh and processing market. Two varietal trials were conducted during the period February – May and July – November 2015 at Graeme Hall, Christ Church (south of the island) and Sweet Vale, St. George (central) to evaluate the performance and quality of three new imported plum varieties of tomatoes against two locally established varieties of tomatoes. The research showed that the imported plum varieties gave lower production compared to the other two locally established varieties but were the preferred choice among consumers based on firmness, size, fleshiness and taste. However, total yields of the imported plum varieties at Graeme Hall were significantly higher at the 1% S.L. when compared to their yield at St. George where significance was at the 5% S.L.

Keywords: Trials, Varieties, Agro-Processing

Introduction

In defining, Food Security at the global level, the Food and Agriculture Organization (FAO, 2001) stated that food security is “when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life.” In October 2013, at the regional level Barbados and its CARICOM Member States used these concepts in establishing a Regional Food and Nutrition Security Policy. This policy is “to ensure that the regional food production, processing, distribution, marketing, trade and food safety and agricultural public health system is capable of providing safe, adequate, nutritious and affordable food for the region's inhabitants at all times thereby achieving food and nutrition security”.

Barbados, a small country with limited resources cannot produce sufficient food to adequately support consumption for its people; due to the many factors that affect production performance at all stages of the production chain (Government of Barbados and the Food and Agriculture Organization of the United Nations, 2013) Most notably are those associated with resources, production, agricultural labour and high input cost. In Barbados, the major food security challenges are poor crop yields as a result of low use of improved crop varieties and inputs as well as minimal application of good agricultural practices. (Ministry of Agriculture Barbados, Medium-term Strategy for the Agricultural Sector 2008-2013).

This has been compounded by climate variability which is changing the weather patterns and therefore making cropping cycles unpredictable. Supply chain management is yet another challenge, leading to high post-harvest losses and the inability of agro-industries to grow. (Ministry of Agriculture Barbados Medium-term Strategy for the Agricultural Sector 2008-2013). With the country's productive natural resource (land) being steadily reduced annually from an estimated 40,000 acres in the 1980's to 28,000 acres in 2016 (Government of Barbados, 2017) agricultural production, has been severely affected and in so doing the country's food security is being progressively hampered. Consequently, the country's food security is increasingly being supported in part by other countries, which has resulted in a high import food bill seen at figure 1. (Agriculture Planning Unit, Barbados 2016). This is exacerbated by limitation to agricultural land some of which are used for non-agricultural purposes.

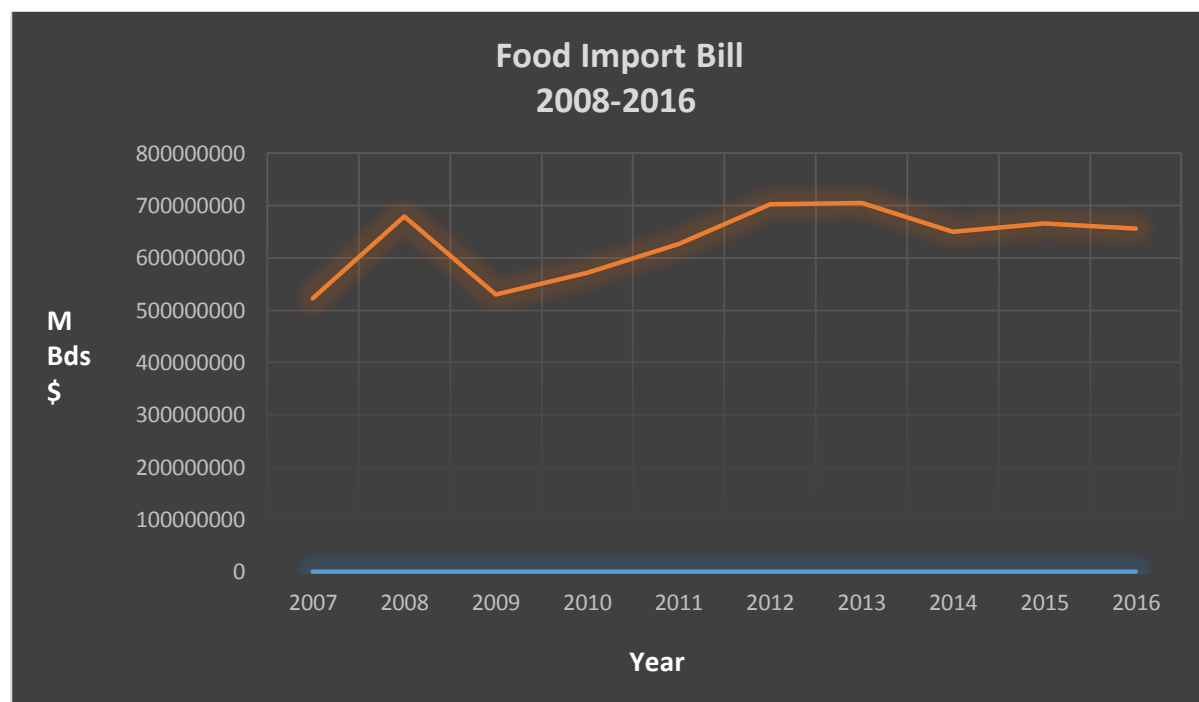
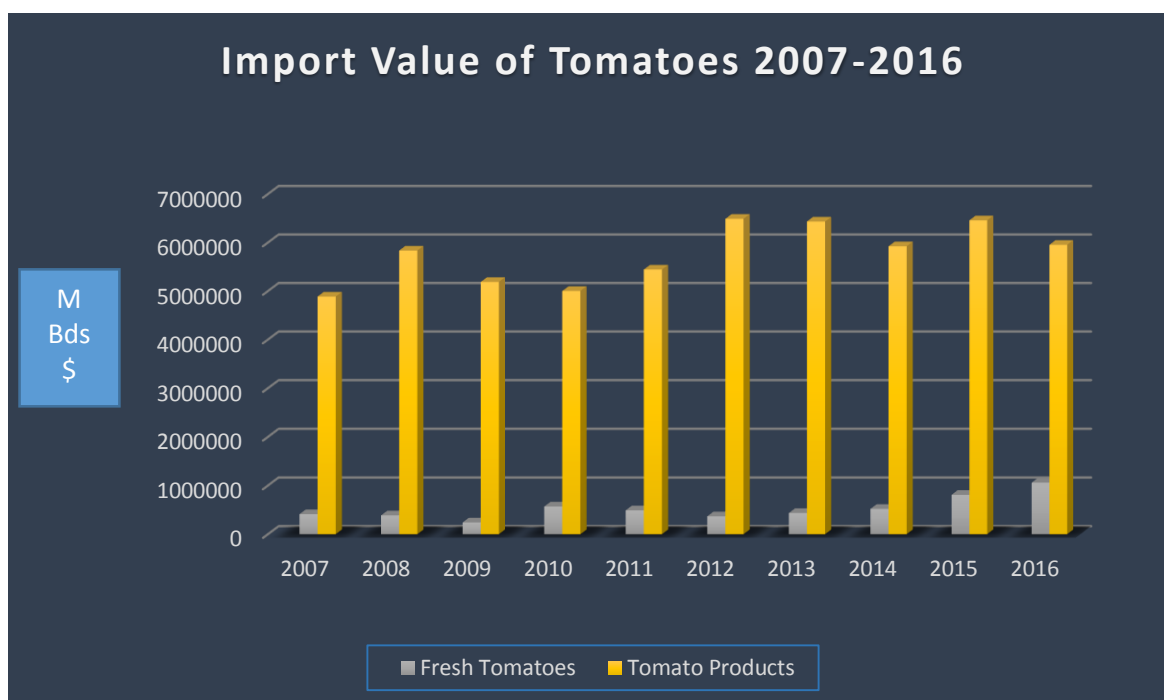


Fig. 1 Food Import Bill for the period 2008-2016
(Agriculture Planning Unit, Barbados, 2016)

Due to Barbados' heavy dependence on imported food the country has been assigned the status of a Net Food Importing Developing Country. The country's food import bill has been steadily rising every year. For the period 2007-2016, the food import bill moved from 522.3 M Bds \$ to

656.1 M Bds \$ giving an increase of 20.4% for the 10 year period. This steady increase over the ten years period has highlighted that the country needs to increase production of local agricultural products and reduce the importation of foods which can be produced locally.

Barbados National Agricultural Policy (2011) analysis of food imports as a percentage of total imports indicated that in 2000 the percentage moved from 15.02% (347.2M Bds \$- food import) to 24.92% (653.8M Bds\$ food import) in 2011 revealing a dramatic rise in food imports. However, in 2009 the food import bill dropped to 530.3M Bds. \$ and continued to rise the following year. In 2016, the country faced a food import bill of 656.1M Bds \$, with tomato and tomato products accounting for 1.1% of overall imports. Of this figure fresh tomatoes totalled 295,334 kgs valuing 1,062,270 Bds \$ with tomato products (ketchup, paste, dried, canned) having a worth of just over 6 M Bds \$ as indicated at figure 2. These huge figures reflect the importance of this vegetable to the island with wide consumption in both the tourism sector and with local inhabitants alike. The Agricultural Planning Unit of the Ministry in 2016 ranked tomato eighth among the vegetable crops base on acreage cultivated (49.5 acres); which consist of 3.48 % of the total vegetable area in the country.



**Fig. 2 Import Value of Tomatoes for the period 2007-2016 (fresh & processed)
(Agriculture Planning Unit, Barbados, 2016)**

Figure 2 also illustrates the impact of imported processed tomato products which the country consumes (Agriculture Planning Unit, Barbados, 2016). Imports of these items accounts for over 90% of the total tomato imports. Barbados has the capability to dramatically reduce this situation by investing in downstream industries and value added goods. The country produces a significant amount of fresh tomatoes as seen in Figures 3 and 4. Of the total fresh tomatoes consumed on the island at least 70% is produced locally with importation making up the deficit. Production fell in 2016 and this is probably due to decrease acreage under production. For the previous year

2015 tomato was ranked second among the vegetable crops with a cultivable acreage of 107.8 acres compared to 49.5 acres in 2016 a decline of 54.1%. (Agriculture Planning Unit, Barbados, 2016)

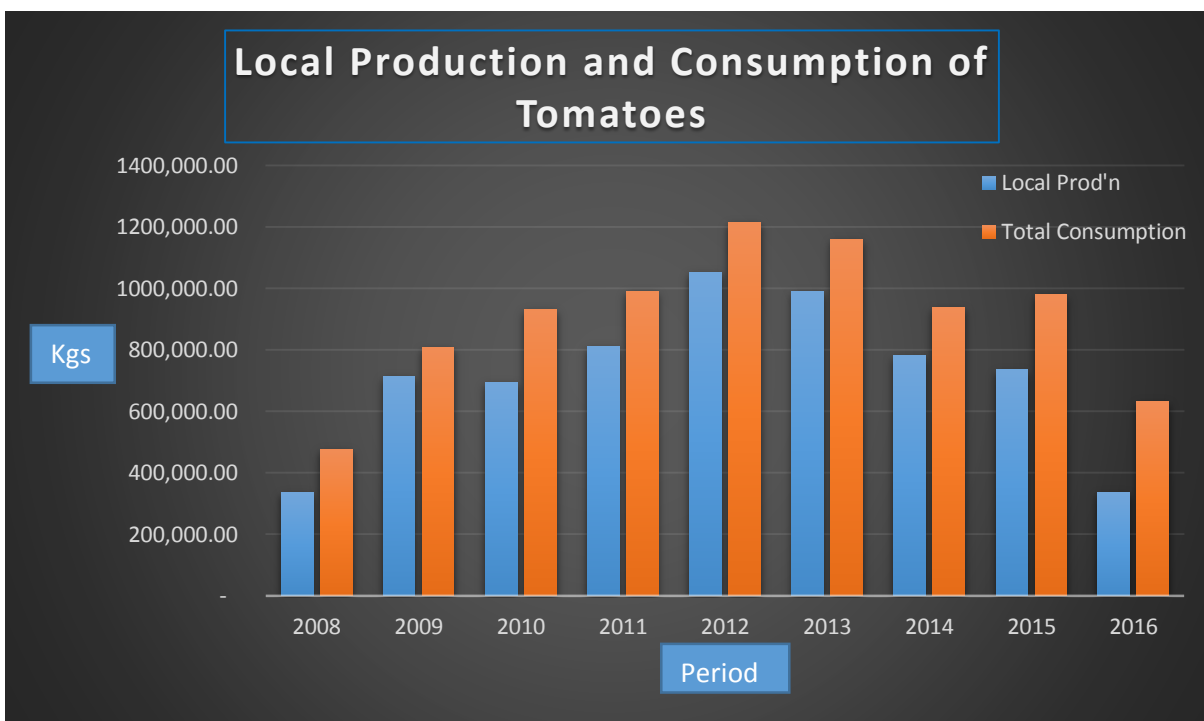


Fig. 3 Local Production of Tomatoes (2008-2016)
(Agriculture Planning Unit, Barbados 2016)

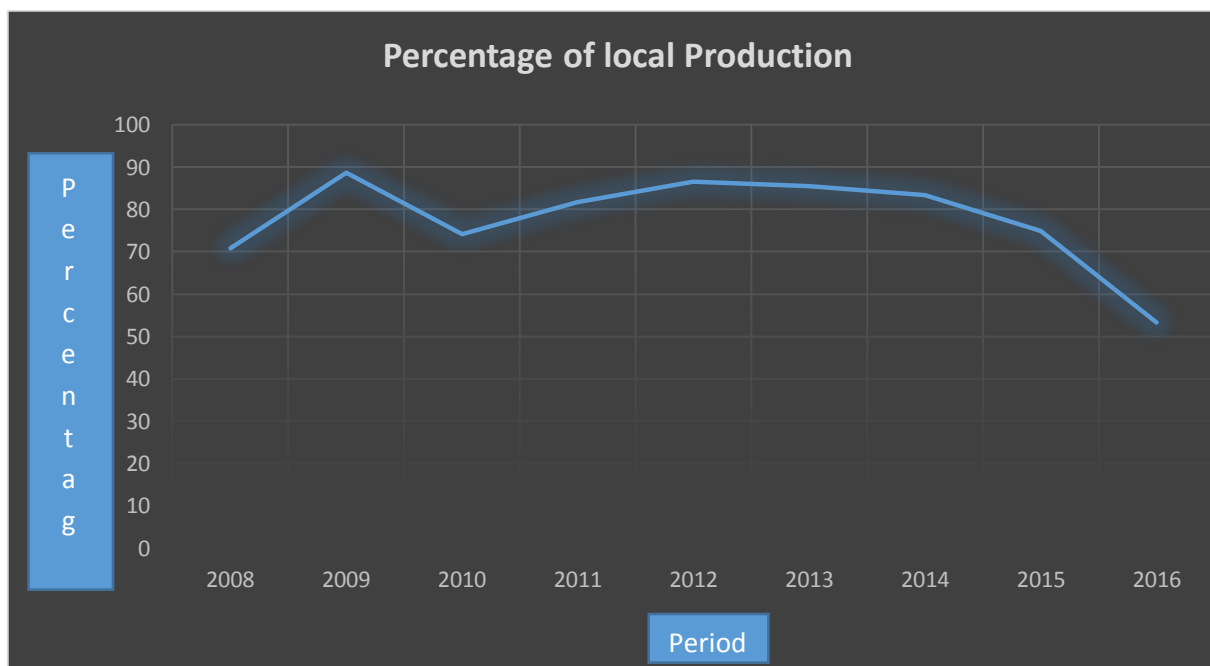


Fig. 4 Percentage of local Production for tomatoes 2008-2016
(Agriculture Planning Unit, 2016)

Background to the Trials

Tomato is considered a vegetable for culinary purposes. As a result, it is incorporated in most dishes based on its acceptable flavour and nutritive value (Abbadi S. Y. A 2010, 361-364). It is a good source of Vitamin A, C and E as well as minerals for protecting the body from diseases (Taylor 1987 cited by Olaniyi J.O. et al 2010, 398-402).

Tomato in Barbados is grown throughout the year mainly in an open field system during the early months of the year (January - June) when there is plenty of sunshine. Production is high (8-12 tons/acre) resulting in gluts in the local market, however, during the rainy season which is the latter half of the year farmers production is low (1- 4 tons/acre) Ministry of Agriculture, Tomato Crop Recommendation #3, 2012). This is due to poor fruit set due to fluctuating temperatures (hot days and cool nights) as well as high humidity, which can lead to poor flower development, flower drop and aborted fruits. Additionally, the crop becomes susceptible to pest and diseases as well as a number of physiological conditions cracking of the fruits and blossom-end rot (Ozores-Hampton and M^c Avoy 2012). These challenges lead to increased unmarketable yield thus considerably reducing production. Although Barbados experiences low production during the rainy season its production is still comparable to the other regional countries as seen at figure 5. The data indicate production for the ten year period 2005-2014 and showed that the country was not only the highest producer regionally but was consistent in producing over seven tons/acre compared to the rest of the region whose production was much lower.

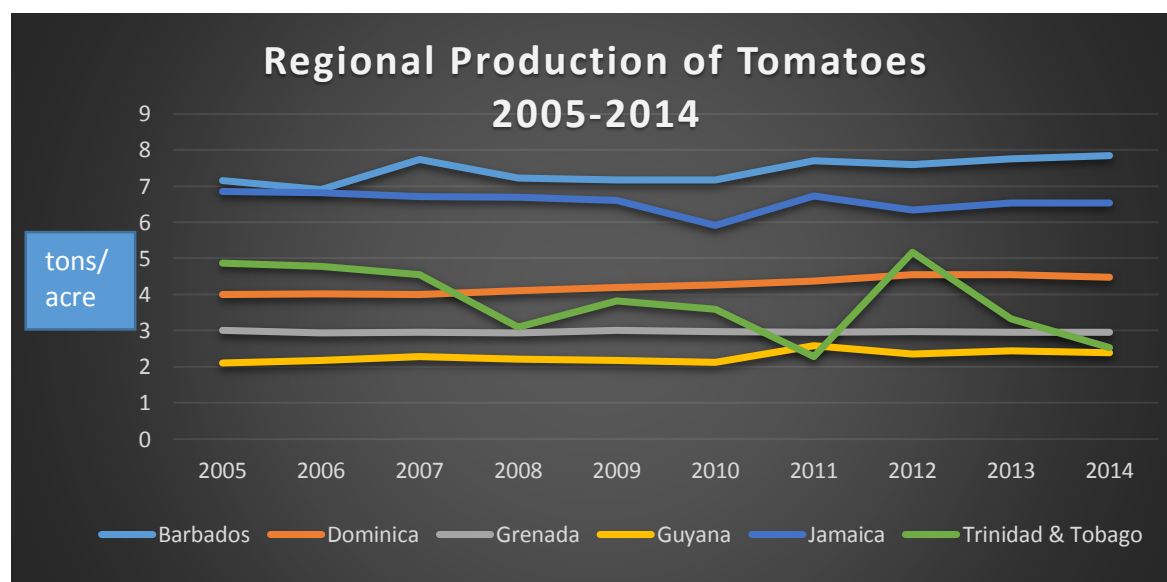


Fig. 5 Regional Production of Tomatoes 2005-2014 (FAOSTAT, 2017)

Managed well tomato production can surpass the expected 8-12 tons per acre in the dry season as well as the wet season yield of 1-4 tons per acre.

Objectives

The objective of these preliminary studies is to evaluate the agronomic performance of three imported plum tomato varieties under local weather conditions against two locally established varieties.

With the specific objectives being to (i) select and recommend varieties to farmers that can withstand the wet conditions (ii) meet the market acceptance criteria of the consumer and by extension the hotel sector. The criteria took into consideration the product's taste (organoleptic quality) and market price as well as the potential contribution to the value added market.

The production cost of the selected variety/varieties would also influence the overall selection all contributing to food production and food security.

Methodology

Tomato Varietal trials

Two tomato varietal trials were conducted during the dry season (February – May, 2015) and the wet season (August – November, 2015). The experiments were conducted at two different locations on the island. The first at Graeme Hall, Christ Church (south of the island) and the other at Sweet Vale, St George (Central). The topography at both sites was slightly sloping with differences in soil type. In the south, the soil was classified as Type 111 (Vernon and Carroll 1966) with a moderate steep to gentle slope, which can lead to excess water in the soil resulting in poor natural drainage. At Sweet Vale, the field was sited in a valley with the dominant slope range 2° - 4° slope. Soils developed from clay deposits resulting poorly drained sub-soil.

Due to the sloping nature of the land and having no knowledge of fertility trends in both locations a Latin Square Design was used.

At both tomato trials the same Latin square design was used except at St. George where five varieties (three imported plum varieties Toliman F1, Tointer F1 and Tocayo F1 and the two locally established varieties HA 3019 and FA 38) were planted compared to four varieties at Graeme Hall where the imported variety Toliman F1 was lost in the seedling stage in the nursery and was therefore eliminated from the Graeme Hall trial.

As a result at Graeme Hall there were four replications compared to St. George which had five replications. Each plot was planted with 14 plants with the inner 10 being monitored for data collection.

Treatments

During land preparation an N.P.K. fertilizer (12-12-17-2) was used as a basal dressing at a rate of 2 bags x 50 kg/acre.

Three weeks after transplanting ammonium sulphate was incorporated using band placement at a rate of 1 bag x 50 kg/acre.

At first fruit set an application of the fertilizer 20-0-18 was used at a rate of 1 bag x 50kg /acre following this, plants were fertigated every two weeks using potassium nitrate 25kg/week until final harvest.

Planting Material:

Seeds were obtained from Bejo Seeds Inc. in Guatemala. All seedlings were produced for the trial by the field staff of the Ministry of Agriculture, Graeme Hall, Christ Church, Barbados.

Transplanting:

Seedlings were transplanted at 18 ins. apart with approximately 14 plants per bed with each plot size 21ft x 5.6ft.

Crop Management

Manual weed control was carried out when needed. Plants were trellised due to their indeterminate nature to avoid rain/water splash as well as keeping the plants more upright thereby protecting the fruits.

Crop management included spraying with Doss, Pirate and Newmectin for leaf miner attack as well as *Heliothus* spp. Calcium Nitrate was used for Blossom End Rot.

Data Collection

Data was gathered with respect to fruit description: Fruit weight, Length of fruit, shape, colour and thickness of flesh.

Data was also collected with respect to production. Harvest started at eight weeks after transplanting and continued weekly for the next six consecutive weeks. All plots were harvested individually. Both marketable and unmarketable fruits were picked, individually weighed and recorded. However, to arrive at a potential weight per plot both weights (marketable and unmarketable) were totalled plus 15% of this total weight was added to give the final weight per plot. The 15% took into consideration field losses – fruits that fell to the ground as well as damaged and immature fruits. Production data for marketable and unmarketable yield were taken from all 10 plants.

Data Analysis

Data were analysed using Genstat 64-bit Release 18.2 (PC/Windows 7) with the assistance of Dr. Francis Lopez, UWI, Cavehill and Microsoft Excel 2013.

Evaluation of the Quality Components

In assessing the quality components of the tomatoes, five varietal characteristics were evaluated with respect to the three varieties of the imported plum tomatoes – average length of fruit, average thickness of the mesocarp (flesh), average weight of fruit, general shape and colour. To measure these parameters with a high level of precision twelve fruits per variety were used and the same twelve fruits were also used to gather the qualitative data. A digital calliper was used to measure the length and thickness of the fruits and a digital scale was used to weigh each fruit. These activities were done in an enclosed room due to the sensitivity of the scale. Data was recorded and averages taken.

Fruit colour was defined by the use of the United States Department of Agriculture (USDA) Visual Aid T.M. – 1(1975) Colour Classification Requirements in Tomatoes, which indicates that when more than 90% of the fruit surface is red the fruit is ripe.

The elongated shape of the fruit was determined using the chart Tomato Fruit Shape Categories adapted from the IPGRI/Biodiversity Protocol 1996 cited by Saccol et al. 2015.

Results:

Comparison of Production Data

Table 1. Production Data - Graeme Hall (Feb – June 2015)

Variety	Prod'n (lbs)	No. of plants	Ave./plt (lbs)
Tointer F1	387	39	10
Tocayo F1	293.75	39	7.5
FA 38	464	33	14
HA 3019	450.5	38	12
S.E. 4.49			
S.L. 15.52			

Table 2. Production Data - Sweet Vale, St. George (July – Nov. 2015)

Variety	Prod'n (lbs)	No. of plants	Ave. /plt (lbs)
Tointer F1	400.2	46	8.7
Tocayo F1	324	45	7.2
FA 38	627.2	49	12.8
HA 3019	540.5	47	11.5
Toliman F1	409.4	46	8.9
S.E. 3.36			
S.L. 10.35			

The data displayed in Tables 1 and 2 shows the yield for each variety in terms of total weight and average weight per plant. In both trials FA 38 and HA 3019 varieties performed better, which was significantly higher when (production: greater than 10 lbs per plant) compared to the performance of the plum varieties which produced less than 10 lbs per plant.

The imported plum varieties are indeterminate which would suggest that production can be increased with improved management to extend the harvesting period.

Table 3. Varietal Characteristics of the Plum Varieties of Tomatoes

Characteristics	Tointer F1	Tocayo F1	Toliman F1
Ave. Length (ins)	2.71	3.05	3.6
Thickness (ins)	0.27	0.33	0.29
Ave. Wt of fruit (ozs)	3	3	3
Shape	Oval	Oval	Oval
Colour	Red	Red	Red

Table 3 compares the varietal features of the three imported varieties of tomatoes giving the average length and thickness of each variety. This data was not statistically analysed but calculated manually. By observation Toliman F1 appears to be the longest of the three with a length of 3.6 inches whereas the length of the other two varieties were 2.71 inches (Tointer F1) and (Tocayo F1) 3.05 inches. Tocayo F1 gave the thickest mesocarp of 0.33 inches, indicating that it is the fleshiest of the three varieties, making it more suitable for the processing market when compared to Toliman F1 and Tointer F, whose thickness of 0.29 and 0.27 inches respectively were slightly lower. The table also shows that all the variety gave an average weight of three ounces per fruit with all fruits elongated in shape and red in colour when ripen.

Quantitative Analysis

Table 4. Analysis of Variance (ANOVA) Comparison

	GRAEME HALL	ST. GEORGE
F-Stat	18.70	3.42
F-pr	.002	.044
	Significant: there is strong evidence to suggest that there are differences in yielding ability among the varieties	Significant: there are differences in production among the varieties.

The ANOVA comparison at table 4 shows significance for both trials at Graeme Hall and St. George. At Graeme Hall significance was high at the 1% SL which indicated that there was strong evidence to suggest that there were differences in yielding ability among the varieties. St. George trial showed significance at the 5% SL which also indicated that there were differences in production among the varieties.

Comparison of the Means

The ANOVA (Analysis of Variance) test showing significance means that at least one of the group tested different from the other groups. However, the ANOVA test does not tell which group differs. Therefore the Fisher's protected LSD test was used to compare the means which can only be used if the null hypothesis is rejected. The results of the test can be seen in Figures. 6 and 7 beneath.

The trial at Graeme Hall as seen in Fig. 6 shows no significant difference between varieties HA 3019 and FA 38, nevertheless, there are differences between the plum varieties Tocayo F1 and Tointer F1. However, the St. George trial shown in Fig. 7 indicates there are no significant differences in mean among the plum varieties Tointer F1, Tocayo F1 and Toliman F1 and further displays that the varieties FA 38 and HA 3019 have no significant difference in the mean between them.

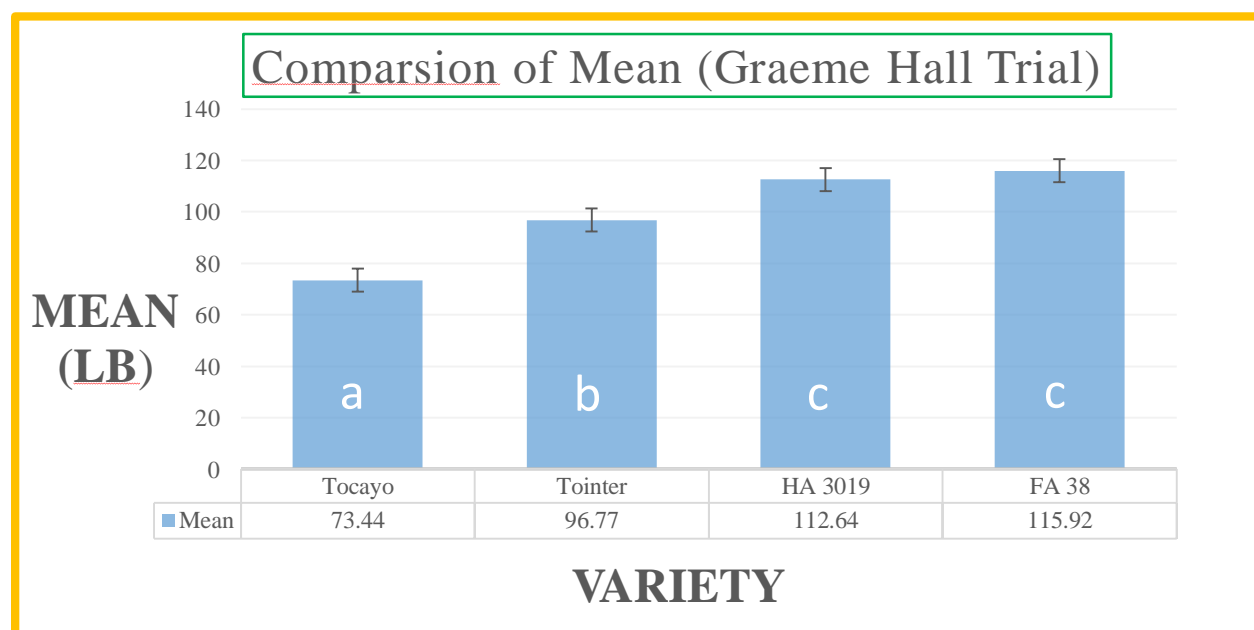


Fig. 6 Comparison of Means of Yield of Tomatoes by Varieties (Graeme Hall Trial)

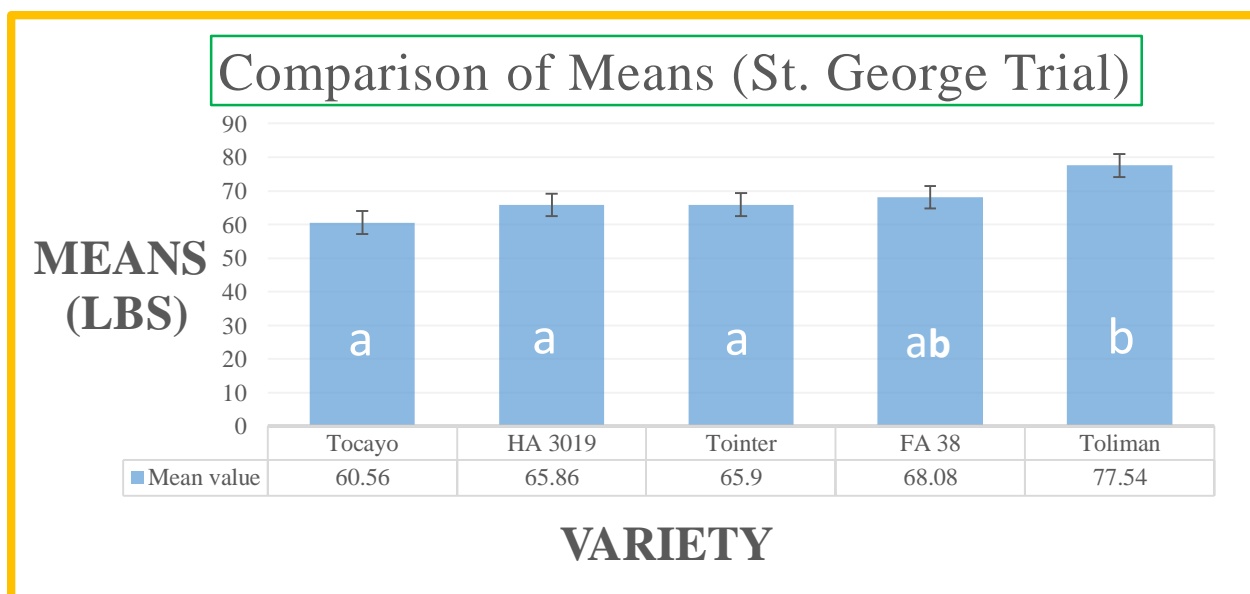


Fig. 7 Comparison of Mean of Tomatoes by Varieties (St. George Trial)

Discussion

Having earned the status of being a Net Food Importing Developing Country and with a rising food import bill Barbados has become quite aware of its position to ensure that the country can provide safe, adequate, nutritious and affordable food to its citizenry at all times (Government of Barbados and the Food and Agriculture Organization of the United Nations 2013). As a result, the country has joined with the other Caribbean Community (CARICOM) Member States to establish a Regional Food and Nutrition Security Policy in October 2010. Committing to this policy the country has started looking within to reduce their dependence on external food imports and look to import substitution. The Agriculture Sector through the Ministry of Agriculture has taken up this challenge and with one of the Ministry's agricultural policy focussing on increasing agricultural production and productivity to improve food security thereby ensuring not only a reliable food supply but also to increase farmers income.

As a result, one of the sector the Ministry has focused attention on is the tomato sector. Considering the huge imports of the fresh produce (tomatoes) as well as its processed products, the Ministry has taken the initiative to further develop the sector by undertaking varietal trials with the objective of selecting varieties for the fresh and processed market. The outcome is to improve the sector by producing tomatoes at a sufficiently high level at a low cost and at the same time maintaining high quality. This will enable the sector to build strong market linkages regionally as well as to develop downstream enterprises, which will enable the domestic market to be competitive with the imported tomato and tomato products.

The two preliminary varietal trials looked at the performance of the plum varieties of tomato under local conditions with an eye towards developing the processing market. Fresh market varieties FA 38 and HA 3019 were already established locally and were used in the trials for comparative purposes. The initial results showed that the plum varieties although lower in production when compared to the established varieties have more potential in the processing

market. Their general characteristics make them more amenable to processing due to their thicker flesh giving a more solid content, their oval shape, as well as fewer locules (less seed). The data also show statistically that among the plum varieties there was no significant difference in yield when the means were compared.

Government's commitment to the tomato sector is seeing further experimental work being undertaken which will be reported at a later date. This drive to revitalize the tomato downstream industry is a result of the government's strategic objective under its commitment to national food and nutrition security is food availability. The Policy statement to this effect states that Barbados will provide an enabling environment to support domestic production, processing and marketing for selected foods for which there are capabilities, comparative advantages and new opportunities for the population (Government of Barbados and the Food and Agriculture Organization of the United Nations 2013). One of the objectives coming from this statement is to increase food availability at an affordable cost to the consumers through increase production and agro-processing with a target of 30% increase in the quantity of domestic commodities. Another indicator include a 15% increase in agro-industries establishment to strengthen the value chain and forge inter-sectoral linkages and in so doing to reduce the food import bill.

The focus on value additions and large scale processing will not only have a significant impact in the sector but can be used as a model to help develop the other agricultural sectors. Additionally, the government has introduced a number of investment strategies to carry the sector forward and to attract investors through its incentive scheme program (Ministry of Agriculture, Food, Fisheries and Water Resource Management 2015) which allows for duty free access for the purchase of agricultural equipment and the rebate incentive of agricultural purchases and investments. The development of the value chain industry will be an incentive for more job creation and an encouragement for more youths to gravitate to the entrepreneurial arm of the sector. This was quite evident when the Ministry in October, 2016 hosted a Product Development Workshop for Tomatoes for stakeholders involved in the production, processing and marketing of tomatoes, which gained national attention. The aim of the workshop was to encourage young entrepreneurs to create new products, learn how to develop markets for their products and in the process acquire the skills of establishing their own business. The workshop was well attended by a cross section of individuals ranging from processors, farmers, suppliers, students and chefs to even product development officers.

Conclusion

In conclusion the imported plum varieties of tomatoes although lower in production have a greater advantage in the processing market than the established local varieties due to their thicker mesocarp, elongated shape and fewer locules (less seeds).

Based on these preliminary findings the Ministry of Agriculture has embarked on the path of researching aspects of the tomato sector by undertaking research work in the sector not only for the benefit of the farmers but by extension the Barbadian populace. In so doing the Ministry will be able to introduce new and more productive tomato varieties which with the adoption of good agriculture practices and best management will be able to surpass the current production potential in the country. With greater production and consistency in supply stakeholders (processors and marketers) can look to further expand and create new sustainable downstream

industries with a view to reducing the food import bill thereby taking the country to a more food secure level.

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