GLADSTONE ROAD AGRICULTURAL CENTRE
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EVALUATION OF FOUR TOMATO (*Lycopersicon esculentum* Mill.) VARIETIES FOR HEAT TOLERANCE

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ABSTRACT

A field trial was conducted at the Gladstone Road Agricultural Centre from March to June 2016. This study evaluated four tomato varieties for heat tolerance in a factorial experimental design with four replications over each of eight harvest dates. The four varieties were 'Big Yellow', 'Christy', 'HA3080' and 'Inbar'. Significant differences were observed between the four 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 'Big Yellow' produced no fruit, while variety 'Christy' produced only a small quantity of marketable fruit. The variety producing the largest number of fruit per plant was 'Inbar' followed by 'HA3080'. The potential yields for the tomato varieties ranged from 1.7 tonnes/hectare for 'Christy' to 6.3 tonnes/hectare for 'Inbar'.

Tomato variety HA3080 grown at the Gladstone Road Agricultural Centre during 2016

Introduction:

The tomato is a winter vegetable crop that prefers cool, dry growing conditions. It thrives best in moderate climates, but can adapt to a wide range of climatic conditions. The tomato can be grown in a variety of soil types, but does best on well-drained, fertile soils. It can be cultivated in the open under field conditions, or in a greenhouse under environmentally controlled conditions. The climate of The Bahamas can be described as cool and dry from October to March and hot and wet from

April to September. The cool season daily temperatures average a low of 18°C (64°F) and high of 25°C (77°F), while the warm season temperatures average a low of 26°C (79°F) and high of 32°C (90°F). In The Bahamas, tomato production is restricted to the cooler months, due to several constraints which severely restrict production during the hot summer months. These constraints, which include heat, heavy rains and humid conditions, result in poor flower development and low fruit set (Sato, *et. al*., 2000). Most of the tomato varieties presently grown by farmers in The Bahamas are sensitive to the hot summer climate, so their availability is limited to the cool season. This inability to tolerate heat stress presents a major challenge for Bahamian farmers in their attempts to produce excellent quality tomatoes in sufficient quantities to satisfy the local market.

The vegetative and reproductive processes of the tomato are adversely affected by high temperature stress, resulting in a reduction in fruit quality and yield (Abdul-Baki, 1991; Alsadon, *et al.,* 2006). Rick (1978) estimates that temperatures above 32°C (90°F) for more than three hours a day is sufficient to induce the abortion of flowers in the tomato. Several researchers (Abdul-Baki, 1991; Wessel-Beaver and Scott 1992; Sato, *et. al*., 2000; Abdelmageed and Gruda, 2009; Elsharief *et. al.,* 2011) have identified heat tolerance in tomatoes by evaluating them for flowering and fruit set, since these two factors are sensitive to heat and relate directly to yield. High temperatures have been shown to affect not only the flowering and early fruiting stages, but also the later development and maturity of the fruit, resulting in reduced yields (Abdul-Baki, 1991; Wessel-Beaver and Scott 1992; Van Der Ploeg and Heuvelink, 2005; Abdelmageed and Gruda, 2009).

Bahamian farmers produce approximately 400 hectares (988 acres) of tomato each year, yielding about 11.0 tonnes/ha (4.9 tons/acre) (FAOSTAT, 2011). The Department of Agriculture has sought to identify heat tolerant tomato varieties by evaluating their performance during the hot summer months. 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 March to June of 2016.

Objective:

This study was conducted to evaluate four tomato varieties and document their performance under growing conditions of The Bahamas, beyond the winter vegetable growing season.

Materials and Methods:

Evaluation of the four tomato varieties was conducted at the Gladstone Road Agricultural Centre during June of 2016. The four varieties were 'Big Yellow', 'Christy', 'HA3080' and 'Inbar'. The open-pollinated heirloom tomato 'Big Yellow' is a medium to large-sized variety of the indeterminate type. Indeterminate tomatoes are the 'vine' types and can 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. Seeds of the variety 'Big Yellow' used in this trial were obtained from seeds saved from a previous harvest of this variety.

The 'Christy', 'HA3080' and 'Inbar' tomato varieties are products of the seed company Hazera Genetics Limited and are distributed by Hazera Seeds Inc. They are determinate, heat tolerant

varieties producing medium to large sized fruits and have very high resistance to tomato yellow leaf curl virus (TYLCV), tomato spotted wilt, Verticillium, Fusarium, and nematodes. 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.

Tomato seeds were planted to a field seedbed during February, 2016. After six days, nearly 100% germination was achieved. Healthy tomato plantlets were selected from the seedbed and planted to field plots on the 6th March, 2016, after approximately 30 days of growth. The 4 x 8 factorial experiment was laid out in a completely randomised design with four replications, using four tomato varieties harvested over eight weeks. Inter-row spacing was 1.5 m (5.0 ft), while within row spacing was 60 cm (2 ft) between plants. The usual cultural practices were observed to ensure that an even stand of plants was maintained in the field plots. Control measures were applied to protect the tomato plots against pest and disease problems. A weekly regime of Bravo® fungicide, alternated with the insecticides Pounce® and Endosulfan®, added to Nutrileaf® liquid fertiliser in a 20-20-20 formulation, was applied on a regular schedule throughout the growing season.

Tomatoes were harvested a total of eight times at weekly intervals from 3rd May to 20th June, after the first mature tomatoes, or crown sets, were green ripened and of a marketable size. For this study, all observations and measurements were made on a total of sixteen plants per variety, four plants for each of the four replications, for each harvest. Fruit displaying catfacing, surface defects, uneven ripening, disease or insect damage were discarded.

The mean monthly maximum temperature for the trial period was recorded at 30.2°C (86.4°F), while the mean monthly minimum temperature was 21.9°C (71.4°F). The total rainfall for the period was 499.3 mm (19.7 in). Mean monthly sunshine duration for the period was 9.1 h. Weather data (Table 1) on maximum and minimum temperatures, rainfall and sunshine duration were obtained from the Meteorological Department of the Commonwealth 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 March to June 2016, 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)
March	**16.5**/0.65	**8.3**	**28.4**/83.1	**20.3**/68.5
April	**23.6**/0.93	**10.2**	**29.1**/84.4	**20.8**/69.5
May	**216.4**/8.52	**9.5**	**30.9**/87.7	**22.0**/71.6
June	**242.8**/9.56	**8.5**	**32.5**/90.5	**24.3**/75.8

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

Statistical Analyses:

All experimental results were analysed using Instat+™ v3.36. Instat is an interactive statistical package, copyright © 2006, Statistical Services Centre, University of Reading, UK. All rights reserved.

Results and Discussion:

Forty-five to fifty days after transplanting, flowers were produced by the varieties 'HA3080' and

'Inbar', followed by fruit set and the development of fully matured tomatoes. The varieties 'Christy' and 'Big Yellow' developed flowers within sixty days after transplanting, however 'Big Yellow' failed to produce any tomato fruit. A small number of fruit was developed by the variety 'Christy'. Analysis of variance (Table 2) 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 was completed on the four tomato varieties. The results revealed a significant effect of variety on all of the yield responses, but no significant effect of harvest date on any of the responses. There was, however, a significant effect of the interaction among variety and harvest date on the yield responses.

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 four tomato varieties. Standard error is for each treatment mean. Error mean square has 511 df. *, ** and *** denote statistical significance at 5, 1 and 0.1% level of confidence, respectively. NS indicates differences between means not significant.

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)
Variety	3	***	***	***	***	***
Harvest Date	7	NS	NS	NS	NS	NS
Harvest Date x Variety	21	***	***	***	***	***
Error	480					
Std. Err.		0.12	22.7	3.97	0.11	21.4

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 four varieties are shown in Table 3. Total fruit weights per plant averaged nearly 0.5 kg of marketable fruit per plant for the three varieties producing fruit. These results were much lower than those of an earlier evaluation of the heat tolerant 'Inbar' variety (Richardson, 2013b). However, they performed favourably compared to several varieties evaluated by Mehraj *et al.*, (2014) and were superior to all four heat tolerant cultivars evaluated by Kugblenu *et al.*, (2013) under semi-arid conditions of West Africa.

Table 3. Mean values of yield responses for four tomato varieties assessed during June, 2016

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)
Big Yellow	0	0	0	0	0
Christy	1.09b	208.1b	86.4b	0.95b	177.9b
HA3080	3.77a	601.1a	149.6a	3.41a	551.5a
Inbar	4.18a	744.1a	170.7a	3.77a	674.7a
Mean	**3.01**	**517.8**	**135.6**	**2.71**	**468.0**

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 three tomato varieties producing fruit, 'Inbar' had the highest marketable fruit weights per plant and the largest number of marketable fruit per plant. This was followed closely by 'HA3080', while 'Christy' yielded less than one third of the top performer. This difference is most likely due to a higher percentage of fruit set by 'Inbar' and 'HA3080'. 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 'HA3080' (8.3%) and 'Inbar' (9.3%), while 'Christy' suffered the highest number of losses for unmarketable tomato fruit at 14.5%.

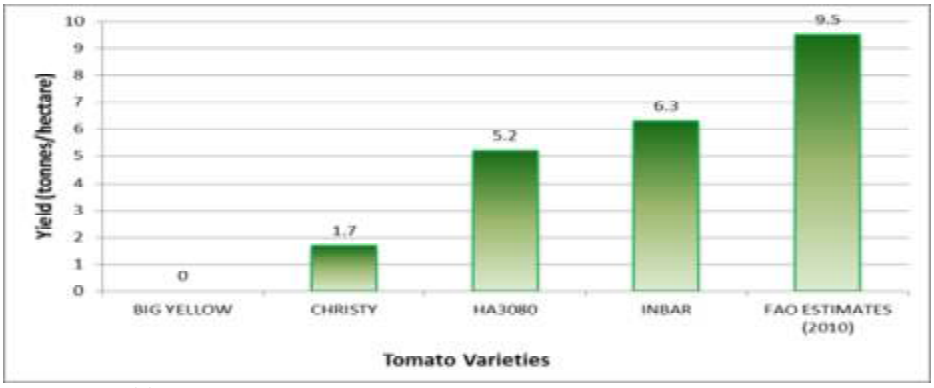

Fig. 1. Potential yields of four tomato varieties evaluated at the Gladstone Road Agricultural Centre during 2016. FAO yield estimates for The Bahamas in 2010 are found in the column at far right.

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 zero to 6.3 tonnes per hectare for the tomato plants, with the variety 'Inbar' presenting the highest mean yields of marketable fruit. The potential yields for the four tomato varieties were not within the range of the latest available FAO tomato yield estimates for The Bahamas.

Table 5. Quality characteristics of four tomato varieties evaluated at the Gladstone Road Agricultural Centre during 2016. *The information for 'Big Yellow' is from previous observations, since this variety did not develop any fruit during the trial period.

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
Big Yellow*	80	-	Medium to large fruit	-	Flattened globe	Golden yellow flesh and skin	-
Christy	60	65	Medium-sized fruit	Well formed, smooth, clean	Globe	Red flesh and red skin	Catfacing
HA3080	60	58	Medium-sized fruit	Well formed, smooth, clean	Globe	Red flesh and red skin	Some surface defects, zipper, Catfacing
Inbar	60	65	Medium-sized fruit	Well formed, smooth, clean	Globe	Red flesh and red skin	Some surface defects, zipper, Catfacing

The 'Inbar' and 'HA3080' tomato varieties exhibited acceptable post-harvest quality characteristics (Table 5), consistent with the basic requirements for the USDA standards for grades of fresh tomatoes (USDA-AMS, 1997). The variety 'Christy' produced fewer marketable fruit. The tomatoes were medium in size, generally well formed and free of defects. There was some evidence of the catface disorder, which occurred, in several fruit, irrespective of size or time of harvest. The variety 'Christy' suffered from the catface disorder more than the other two varieties (Plate 1).

Plate 1. Catfacing on ripening fruit of 'Christy' tomato

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. Catfacing was not as severe as in previous tomato trial (Richardson, 2013a), most likely due to the warmer conditions during flowering and fruiting.

From the results of this study it can be seen that three of the tomato varieties exhibiting heat tolerance are suitable for cultivation during the warmer months of the year and can be used to extend the growing season. These varieties may be considered for further evaluation 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.

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