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Effects of cultivar, maturity stage and Ethrel treatment on ripening and fruit quality of tomato (*Solanum lycopersicum* L.)

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ABSTRACT

This study was conducted with the objective of determining the effects of maturity stage at harvest and Ethrel treatment on ripening and fruit quality of selected tomato cultivars. The experiment was conducted in the laboratory of biochemistry at the Faculty of Agricultural Sciences, University of Gezira, Wad Medani, Sudan, during the seasons 2009/10 and 2010/11. Cultivars used were Vt 925, Castle Rock and Peto 86. Maturity stages were mature green and breaker. Ethrel treatments were 0 ml/L and 2 ml/L. Treatments were arranged in a completely randomized design with three replicates. Results showed that the cultivar Vt 925 had the largest fruits and the highest ascorbic acid and TSS contents as compared to the other two cultivars in both seasons. Results also showed that advancement of maturity stage significantly decreased fruit green life in both seasons, however, total soluble solids were slightly increased with an increase in tomato fruit maturity stage. Titratable acidity decreased slightly with the advancement of maturity stage. Fruit maturity stage had no significant effects on ascorbic acid content in both seasons. Ethrel treatment significantly increased uniformity of ripening and ascorbic acid content, but decreased fruit green life in both seasons, however, it had no significant effects on TSS and acidity. It is recommended to grow the cultivar Vt 925, harvest fruits at the mature green stage and treat them with Ethrel at destination markets in order to achieve uniformity of ripening, to extend their shelf life and end up with high fruit quality.

INTRODUCTION

Tomato (*Solanum lycopersicum* L.) is one of the most important and popular vegetables worldwide. The fruits are an important source of minerals such as K, Ca, Fe, Mg and P, in addition to carotenoids especially lycopene, and vitamins A, B and C (Causse *et al.*, 2003). Moreover, results from the epidemiological studies have shown that tomato and its products may have positive effects against various forms of cancer, especially prostate cancer and cardiovascular diseases (Ellinger *et al.*, 2006).

The maturity stage of harvested perishable commodities has important effects on the way they are handled, transported , marketed and on their storage life and quality (Garray, 2006). Tomato can be harvested at a number of maturity stages, depending on distance to the market and intended purpose. For long distance transport, fruit should be harvested at the mature-green stage. Fruit destined for local market can be harvested at the pink or breaker stage and tomato for processing is harvested at the full ripe stage. Harvesting tomatoes at the mature-green stage for fresh market is intended to facilitate post-harvest handling of fruits that are still firm enough to

withstand shipping and handling (Hong and Gress, 2001).

Shelf life is the most important aspect in loss reduction of fruits and vegetables. Sasivimon *et al.* (2002) reported that the shelf life of all tomato cultivars were longest when harvested at the mature-green stage. Although fruits harvested at later ripeness stages, i.e., turning, pink or red, possess higher sensory quality at the red stage, yet those fruits are less tolerant to the current handling and marketing systems (Garcia and Barrett (2012).

High quality tomato fruit has a firm turgid appearance, uniform and shiny color, without signs of mechanical injuries, shriveling or decay (Hong and Gress, 2001). Titratable acidity (TA) is an important factor in fruit processing industry and cultivars with a high TA are not suitable for processing. Seung and Kader (2000) found that the maximum acidity can be reached at the pink stage of ripening. They also reported that sugar content increased during maturation from the mature-green to the red ripe stage, and the sugar content depended on the stage of ripening.

Mature-green tomatoes are usually treated at shipping points with 100 ppm ethylene for 24-48 hr at 20-25^{0}C and 85-90% relative humidity to ensure homogeneous ripening (Garray, 2006). Although 1-10 ppm ethylene is sufficient to induce ripening, however, higher concentrations are used to ensure the treatment of fruit located in the center of the containers and pallets, and to compensate for leakage of ethylene out of the ripening room. Also, the high levels of CO_2 inside the ripening room, which results from the process of respiration, inhibit ethylene action on ripening.

The recommended treatment procedure is to keep CO_2 level below 0.2% by using adequate air exchange (Ishida, 2000). Ethylene treatment not only maintains fruit quality but also assures homogeneity of ripening of fruits (Pangaribuan, 2009). Ethylene enhances both vitamin C and β carotene contents of tomatoes. Mature-green tomatoes treated with 8 ppm ethylene for 24 hr and then ripened, had 16% higher vitamin C content than untreated fruits (Seung and Kader (2000). Therefore, the objective of this study was to determine the effects of maturity stage and ethylene treatment on ripening and fruit quality of selected tomato cultivars.

MATERIALS AND METHODS

Experimental site

Experiments were conducted in the laboratory of biochemistry, Faculty of Agricultural Sciences, University of Gezira, Wad Medani, Sudan, during the seasons 2009/10 and 2010/11 to determine the effects of maturity stage and ethylene treatment on ripening and fruit quality of selected tomato cultivars. The cultivars used were hybrid Vt 925, Castle Rock and Peto 86.

Source of fruits and experimental layout

Tomato fruits of hybrid Vt 925 were obtained from the Experimental Farm, University of Gezira, Wad Medani, Sudan. Fruits of cultivars Peto 86 and Castle Rock were obtained from the local market, Wadmedani, Sudan.

Treatments consisted of three cultivars, namely, Vt925, Peto 86 and Castle rock, two maturity stages, namely, mature-green and breaker and two ethylene concentrations: 0 ml/L and 2 ml/L ;

giving a total of 12 treatments. Treatments were arranged in a completely randomized design with three replicates.

Data collected

Tomato fruits were harvested at the mature-green and breaker stages and weighed. Carpel thickness and fruit cavity were determined using a vernier caliper. Total soluble solids (TSS) were determined using a hand refractometer (Model HRN-32).

Titratable acidity was determined on a 5 ml juice diluted with 200 ml of distilled water and titrated against 0.1 N NaOH to phenolphthalein end point (light pink color) and calculated as percentage of citric acid.

$$\text{Titratable acidity} = \frac{\text{mls of NaOH x Normality of NaOH x 0.064 x 100}}{\text{Volume of juice (ml)}}$$

Ascorbic acid was determined using the iodine method. An amount of 400 mg of iodine was dissolved in 100 ml of H_2O. Then, 25 ml of dilute H_2SO_4 was added to make a solution of 0.1 N iodine. One ml of 0.1 N iodine is equivalent to 8.8 mg ascorbic acid /100 ml of juice.

Starch solution was prepared by taking one gram of wheat flour and dissolving it in 100 ml of H_2O and then boiled and cooled. One ml of tomato juice was taken and diluted with 25 ml of distilled water and 10 drops of starch solution were added and then titrated against 0.1 N iodine to a blue - black color end point.

Calculation:

Ascorbic acid (mg/100ml) = ml of iodine x 8.8 x dilution factor (25)

Effect of Ethrel application on tomato fruit ripening

This part of the experiment was conducted at the ripening room of the National Institute for the Promotion of Horticultural Exports, University of Gezira, Wad Medani, Sudan, to study the effects of Ethrel application on tomato fruit ripening. Fruits at the mature green and breaker stages from Vt 925, Peto 86 and Castle Rock were washed, disinfected and then treated with 0 ml and 2 ml Ethrel/liter (Ethrel^R-France) for two minutes which were equivalent to 0 ppm and 100 ppm of ethylene hormone. Fruits were placed on tables and left to ripen at 25^0C. Treatments were arranged in a completely randomized design with three replicates. The fruit green life, titratable acidity, TSS and vitamin C at the ripe stage were determined.

Statistical analysis

Data were subjected to the analysis of variance procedure using MSTAT computer program. Means separation was done using Duncan's Multiple Range Test.

RESULTS AND DISCUSSION

Physicochemical characteristics of tomato cultivars

There were significant differences among tomato cultivars in all parameters tested (Table1).

The cultivar Vt 925 produced significantly larger fruits with thicker carpels and larger fruit cavity in both seasons as compared to the other two cultivars. However, Peto 86 produced the lowest values in both seasons. Similar results were reported by Purkayastha and Mahanta (2011) who found that tomato fruit weights of five cultivars ranged from 49.6 g to 64.2 g. Garavand *et al.* (2011), working with three tomato cultivars, found that fruit cavity ranged from 4.5 cm to 5.7 cm. Our results showed a range of fruit cavity from 3.4 cm to 4.4 cm. Purkayastha and Mahanta (2011) found that carpel thickness ranged from 0.47 to 0.57 cm. Our results showed a range of carpel thickness from 0.48 to 0.68 cm.

Table 1. Physical characteristics of three tomato cultivars.

Cultivar	Fruit weight (g)	Carpel thickness (cm)	Cavity diameter (cm)
	Winter (2010)		
Vt 925	98.89 a	0.64 a	4.35 a
Castle Rock	73.44 b	0.52 b	3.89 b
Peto 86	64.74 c	0.57 b	3.75 c
Sig. level	**	*	**
CV (%)	15.24	8.43	7.58
	Summer (2011)		
Vt 925	81.62 a	0.68 a	4.15 a
Castle Rock	70.32 b	0.58 b	3.82 b
Peto 86	66.28 c	0.48 c	3.40 c
Sig. level	**	*	**
CV (%)	12.29	10.14	6.34

Means in columns having the same letter(s) are not significantly different at $P \leq 0.05$ level according to Duncan's Multiple Range Test.
* and ** indicate significance at $P \leq 0.05$ and 0.01, respectively.

The chemical composition of the three tomato cultivars is shown in Table 2. Significant differences were observed in titratable acidity, total soluble solids and vitamin C content in both seasons. The cultivar Castle Rock had the highest titratable acidity, followed by Peto 86, whereas Vt 925 had the lowest value in both seasons. Adubofuor *et al.* (2010) working with three tomato cultivars found that titratable acidity of tomato fruit ranged from 0.20 to 0.83. Our results showed a range of TA from 0.50 to 0.83.

Total soluble solids and vitamin C contents were significantly higher in fruits obtained from Vt 925 cultivar, whereas Peto 86 fruits recorded the lowest values in both seasons. Purkayastha and Mahanta (2011) working with five tomato cultivars found that TSS ranged from 3.6% to 5.4%. Our results showed a range of TSS from 4.5% to 4.8%.

The cultivar Vt 925 had the highest vitamin C content followed by Castle Rock, whereas Peto 86 had the lowest value in both seasons (Table 2). These results suggest that this cultivar can be recommended to be grown for fresh consumption due to its high vitamin C content. Similar results were reported by Adubofuor *et al.* (2010) who found that tomato vitamin C content ranged from 20.2 to 30.8 mg/100g fresh weight.

Table 2. Chemical composition of three tomato cultivars.

Cultivar	Titratable acidity (% citric acid)	TSS (%)	Vitamin C (mg/100g fresh wt.)
	Winter (2010)		
Vt 925	0.50 c	4.83 a	31.18 a
Castle Rock	0.81 a	4.63 b	24.77 b
Peto 86	0.70 b	4.62 b	16.51 c
Sig. level	*	*	**
CV (%)	9.87	5.90	7.60
	Summer (2011)		
Vt 925	0.51 c	4.75 a	30.43 a
Castle Rock	0.83 a	4.62 b	23.43 b
Peto 86	0.72 b	4.50 c	18.69 c
Sig. level	*	*	*
CV (%)	9.97	6.54	8.24

Means in columns having the same letter(s) are not significantly different at P≤0.05 level according to Duncan's Multiple Range Test.
* and ** indicate significance at P≤0.05 and 0.01, respectively.

The main effects of maturity stage on fruit chemical characteristics and fruit green life are shown in Table 3. Maturity stage had no significant effects on the chemical characteristics of tomato fruits in both seasons. However, total soluble solids slightly increased with an increase in tomato fruit maturity. These findings were similar to the results reported by Garcia and Barrett (2012). Titratable acidity decreased slightly with the advancement of maturity. Maximum acidity (0.63%) was found in mature green tomatoes, which was decreased with the progress of maturity. Fruit maturity stage had no significant effects on vitamin C content. The values were similar to those reported by Seung and Kader (2000). Fruit green life of tomato was significantly affected by maturity stage and decreased with the advancement of maturity in both seasons. Mature green tomatoes reached the turning stage after 5 days while those of the breaker stage took only 3 days. Similar results were also reported by Adedji *et al.* (2006) who found that mature green tomatoes reached the turning stage after 5.33 days and the breaker stage took three days.

Table 3. The main effects of maturity stage at harvest on fruit chemical characteristics and fruit green life.

Maturity stage	TSS (%)	TA (% citric acid)	Vit C (mg/100g fresh wt.)	Green life (days)
		Winter (2010)		
Mature green	4.63	0.61	23.85	5.61 a
Breaker	4.67	0.59	24.97	3.74 b
Sig. level	NS	NS	NS	**
CV(%)	6.60	8.38	7.60	9.23
		Summer (2011)		
Mature green	4.67	0.63	23.64	5.61 a
Breaker	4.72	0.60	24.46	3.79 b
Sig. level	NS	NS	NS	**
CV(%)	5.40	9.87	8.24	7.85

Means in columns having the same letter(s) are not significantly different at P≤0.05 level according to Duncan's Multiple Range Test.
**and NS indicate significance at P≤0.01 and not significant, respectively.

The effects of Ethrel treatment on fruit green life, uniformity of ripening and fruit chemical characteristics are shown in Table 4. Ethrel treatment had significant effects on fruit green life, uniformity of ripening and vitamin C content in both seasons. Ethrel treatment significantly decreased fruit green life in both seasons. This is because ethylene hormone, which is released from Ethrel, accelerated ripening of tomato fruits as compared to the untreated control. Similar results were reported by Elkashif and Mahmoud (2005) who found that ethylene treatment not only maintained banana fruit quality but also shortened the ripening time and resulted in more homogeneously ripened fruits. Our results showed a range of uniformity in ripening from 40.8% to 80.7% compared to the control. Ethrel treatment had
no significant effects on fruit TSS content and titratable acidity in both seasons. Similar findings were reported by Purkayastha and Mahanta (2011) who worked on different tomato cultivars and found no significant differences between Ethrel treated and untreated fruits with respect to total soluble solids and titratable acidity. The application of Ethrel significantly increased vitamin C content of tomatoes from 16.5 to 31.8 mg/100 g fresh

weight in both seasons. These results reveal the nutritional advantage of exposing tomatoes to ethylene hormone.

Table 4. The main effect of Ethrel application on fruit green life, uniformity of ripening and chemical characteristics of tomato fruit.

Ethrel conc (ml/L)	Green life (days)	Uniformity of ripening (%)	TSS (%)	TA (% citric acid)	Vit C (mg/100g fresh wt.)
		Winter (2010)			
0	6.00 a	40.78 b	4.40	0.58	16.51 b
2	3.55 b	80.66 a	4.43	0.59	31.81 a
Sig. level.	**	**	NS	NS	**
CV (%)	9.23	4.52	6.54	9.87	7.60
		Summer (2011)			
0	6.09 a	40.89 b	4.37	0.50	18.29 b
2	3.61 b	80.67 a	4.40	0.58	24.55 a
Sig. level.	**	**	NS	NS	**
CV (%)	7.85	8.64	5.90	8.38	8.24

Means in columns having the same letter(s) are not significantly different at P≤0.05 level according to Duncan's Multiple Range Test.
**and NS indicate significance at P≤0.01 and not significant, respectively.

The interaction effects of tomato cultivar and maturity stage on fruit chemical characteristics are shown in Table 5.There were no significant differences in TSS and titratable acidity among treatments in both seasons. However, in all cultivars, there was a slight increase in TSS and a decrease in titratable acidity in the breaker stage of fruit maturity in both seasons. This finding is similar to the results reported by Garcia and Barrett (2012) and Radzovicinus *et al.* (2012) who found that total soluble solids increased slightly with maturity advancement.

Titratable acidity in all cultivars decreased slightly with the advancement of maturity. Similar results were also reported by Adubofuor *et al* (2010) who found that variations in tomato acidity were mostly attributed to maturity stage rather than genetic differences.

Vitamin C content in all cultivars was significantly increased with advancement of fruit maturity in both seasons. The highest vitamin C content was recorded for the cultivar Vt 925 harvested at the breaker stage in both seasons. Generally, vitamin C content in all cultivars was higher in the breaker stage than in the mature green stage (Table 5). Our results showed a range of vitamin C content from 16.5 to 33.0 mg/100g fresh weight. These results were similar to those found by Radzovicinus *et al.* (2012) who found that the average vitamin C content of fully ripe tomatoes, which had been picked at different maturity stages, ranged from 10 to 20 mg /100 g fresh weight. Our results support the findings of these previous workers who reported that the amount of vitamin C content mainly depended on tomato genotype rather than maturity stage.

Table 5. Interaction effects of tomato cultivar and maturity stage on fruit chemical composition.

Cultivar	Maturity stage	TSS (%)	TA (% citric acid)	Vit C (mg/100g fresh wt.)
		Winter (2010)		
Vt 925	Mature green	4.67	0.65	24.34 b
	Breaker	4.83	0.55	33.02 a
Castle Rock	Mature green	4.48	0.63	22.01 d
	Breaker	4.62	0.62	27.51 c
Peto 86	Mature green	4.58	0.62	16.51 f
	Breaker	4.64	0.61	17.51 e
Sig. level		NS	NS	**
CV (%)		6.54	9.87	7.60
		Summer (2011)		
Vt 925	Mature green	4.80	0.65	25.68 b
	Breaker	4.87	0.57	31.19 a
Castle Rock	Mature green	4.62	0.59	20.17 d
	Breaker	4.63	0.57	22.01 c
Peto 86	Mature green	4.58	0.60	16.51 f
	Breaker	4.65	0.58	18.34 e
Sig. level		NS	NS	**
CV (%)		5.90	8.38	8.24

Means in columns having the same letter(s) are not significantly different at P≤0.05 level according to Duncan's Multiple Range Test.
**and NS indicate significance at P≤0.01 and not significant, respectively.

The interaction effects of maturity stage and Ethrel treatment on fruit green life, uniformity of ripening, TSS, TA and vitamin C are shown in Table 6. Significant interaction effects of maturity stage and Ethrel treatment were observed on fruit green life, uniformity of ripening and vitamin C content in both seasons. Ethrel treatment at both maturity stages significantly reduced fruit green life in both seasons. The longest fruit green life was obtained by the cultivars Castle Rock and Peto 86 harvested at the mature green stage and untreated by Ethrel, whereas, the shortest green life was given by the cultivar Vt 925 harvested at the breaker stage and treated with Ethrel in both seasons. Similar findings were reported by Ishida (2000) who found that Ethrel treatment significantly accelerated fruit ripening as indicated by the short time required for fruits to reach the red ripe stage in comparison with the control.

Treatment of tomato fruits with Ethrel increased the uniformity of ripening to 80% as compared to the control (40%) in both seasons. Similar results were reported by Sasivimon *et al.* (2002) who found that treating tomatoes with ethylene immediately after harvest and keeping them at 20C, ripened faster and were more uniform than the untreated control. The application of Ethrel had no significant effects on fruit TSS and titratable acidity in both seasons. Similar findings were reported by Pangaribuan (2009) who found that ethylene treatment did not significantly affect total soluble solids and titratable acidity.

Regardless of Ethrel treatment, harvesting fruits at the breaker stage resulted in a slight increase in TSS and a small decrease in TA in both seasons. Similar results were reported by Anthon *et al.* (2011) who found that TA was slightly decreased with an increase in tomato

maturity and TSS contents were increased with advancement of maturity stage. Regardless of maturity stage, Ethrel treatment significantly increased vitamin C content in both seasons. This positive effect of ethylene hormone on vitamin C content has also been reported by Sasivimon *et al.* (2002) who found that the highest vitamin C content was found in fruits which were harvested at the breaker stage and treated with ethylene.

Table 6. Interaction effects of maturity stage at harvest and Ethrel treatment on fruit green life, TSS, uniformity of ripening and chemical composition of tomato fruit.

Maturity stage	Ethrel conc. (ml/L)	Green life (days)	Uniformity of ripening (%)	TSS (%)	TA (% citric acid)	Vit C (mg/100 g fresh wt.)
			Winter (2010)			
Mature green	0	6.79 a	40.33 c	4.39	0.66	14.68 d
	2	4.44 c	80.67 a	4.40	0.61	30.02 b
Breaker	0	5.22 b	60.22 b	4.87	0.64	18.34 c
	2	3.66 d	80.66 a	4.88	0.61	33.57 a
Sig. level		**	**	NS	NS	**
CV (%)		9.23	4.48	6.54	9.87	7.60
			Summer (2011)			
Mature green	0	6.66 a	40.44 c	4.37	0.65	14.60 d
	2	4.55 c	80.68 a	4.40	0.64	30.02 b
Breaker	0	5.11 b	60.33 b	4.43	0.61	16.89 c
	2	3.60 d	80.68 a	4.49	0.61	31.68 a
Sig. level		**	**	NS	NS	**
CV (%)		7.85	7.64	5.90	8.39	8.24

Means in columns having the same letter(s) are not significantly different at $P \leq 0.05$ level according to Duncan's Multiple Range Test.
**and NS indicate significance at $P \leq 0.01$ and not significant, respectively.

Interaction effects of tomato cultivar, maturity stage and Ethrel treatment on vitamin C content and fruit green life were significant in both seasons (Table7). The highest vitamin C content was obtained by the cultivar Vt 925 harvested at the breaker stage and treated with Ethrel, followed by Castel Rock, whereas the lowest vitamin C content was given by Peto 86, harvested at the mature green stage and without Ethrel treatment in both seasons. Similar results were also reported by Seung and Kader (2000) who found that vitamin C content in fruits and vegetables could be influenced by various factors such as genotype , maturity stage at harvest, cultural practices and post-harvest handling conditions. The longest green life was obtained by the cultivars Castle Rock and Peto 86 harvested at the mature green stage and untreated by Ethrel in both seasons. However, the shortest green life was

given by the cultivar Vt 925 harvested at the breaker stage and treated with Ethrel in both seasons.

Similar results were reported by Sasivimon *et al.* (2002) who found that Ethrel treatment had significantly accelerated fruit ripening as indicated by the short time required for fruits to reach the red ripe stage in comparison with the untreated control.

In conclusion, it is recommended to grow the tomato cultivar Vt 925, harvest fruits at the mature green stage and treat them with Ethrel at destination markets so as to obtain uniformly ripened fruits with excellent chemical composition and long green life.

Table 7. Interaction effects of tomato cultivar, maturity stage and Ethrel treatment on vitamin C content and fruit green life.

Cultivar	Maturity stage	Ethrel conc. (ml/L)	Vit C (mg/100 g fresh wt.)	Fruit green life (days)
		Winter (2010)		
Vt 925	Mature green	0	22.5 e	6.7 b
		2	36.3 b	3.6 e
	Breaker	0	22.1 e	4.8 d
		2	44.6 a	2.9 f
Castle Rock	Mature green	0	11.4 g	7.6 a
		2	30.2 d	4.8 c
	Breaker	0	22.3 e	5.7 c
		2	33.2 c	3.3 e
Peto 86	Mature green	0	11.8 g	7.6 a
		2	21.3 f	5.4 c
	Breaker	0	11.9 g	5.8 c
		2	22.7 e	3.6 e
Sig. level			**	*
CV (%)			7.60	7.85
		Summer (2011)		
Vt 925	Mature green	0	19.1 f	6.2 b
		2	36.7 b	3.3 e
	Breaker	0	21.5 e	4.5 d
		2	44.3 a	2.2 f
Castle Rock	Mature green	0	11.8 g	7.2 a
		2	29.7d	4.5 c
	Breaker	0	21.9 e	5.3 c
		2	30.4 d	3.1 e
Peto 86	Mature green	0	11.5 g	7.2 a
		2	20.8 e	5.1 c
	Breaker	0	11.1 g	5.3 c
		2	22.3 e	3.2 e
Sig. level			**	**
CV (%)			8.24	7.85

Means in columns having the same letter(s) are not significantly different at P≤0.05 level according to Duncan's Multiple Range Test.

* and ** indicate significance at P≤0.05 and0.01, respectively.

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تأثير الصنف وطور النضج والمعاملة بالإثرل على إنضاج ونوعية ثمار الطماطم (*Solanum lycopersicum* L.)

محمد الحاج الكاشف و مشاعر سالم حسين و عثمان محمد الامين

كلية العلوم الزراعية ، جامعة الجزيرة ، واد مدني ، السودان

الخلاصة

تهدف هذه الدراسة لتحديد أثر الصنف وطور النضج والمعاملة بالإثرل على نضج ونوعية ثمار الطماطم. أجريت التجربة بكلية العلوم الزراعية، جامعة الجزيرة، ود مدني، السودان، خلال موسمي 2009/10 و2010/11 الأصناف المستخدمة هي Vt925، Castle Rock، Peto 86، تم الحصاد في طوري البلوغ الاخضر والنجمة وكانت تراكيز الاثرل المستخدم هي 0 و 2ml/L ml. نظمت المعاملات بالتصميم العشوائي الكامل بثلاث مكررات. تمت دراسة الصفات الفيزيائية والكيميائية لثمار الطماطم وقد أوضحت النتائج أن الصنف Vt925 أنتج ثمارا أكبر حجماً وتحتوي على أعلى نسبة من فيتامين ج (Ascorbic acid) والمواد الصلبة الذائبة (TSS) مقارنة مع الأصناف الأخرى للموسمين معاً. حصاد الثمار في طور النجمة أدى لنقص معنوي في عدد الأيام اللازمة للوصول لطور النضج، كما أدى لزيادة ملحوظة في محتوى الثمار من المواد الصلبة الذائبة مما ادي لنقص طفيف في حمض الستريك (Citric acid)، معاملة الثمار بالإثرل أدى لزيادة معنوية في نسبة تجانس النضج و محتوى الثمار من فايتامين ج ، كما أدى لنقص معنوي في عدد الأيام اللازمة للوصول لطور النضج فيما لم يؤثر على محتوى الثمار من المواد الصلبة الذائبة وحمض الستريك. يوصى بزراعة الصنفVt925 على أن يتم الحصاد في طور البلوغ الاخضر وتعامل الثمار بالإثرل لإطالة العمر التخزيني والمحافظة على جودة الثمار.