

Are genotypes of hybrid tomato adequate to getting high yield and quality?

Hibrit domates genotipleri yüksek verim ve kaliteye ulaşmak için yeterli midir?

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ARTICLE INFO

Received 07 November 2016
Received in revised form 15 March 2017
Accepted 28 March 2017

Keywords:

Tomato
Performance
Producer
Greenhouse
Environmental variation

ABSTRACT

Genetic capacity and production practices determine yield and quality of crops. The objective of this study was to determine the effects of hybrid tomato cultivars and producers on the yield and quality. The plant materials included five commercial tomato hybrids (Yeliz, Lamia, 7806, Asil and Mira). The plants were grown in 12 different greenhouses, managed by individual farmers, in Antalya, Turkey, in the fall growing season of 2013-2014 (August to March). Both the cultivar and producer effects were significant ($p < 0.05$). Of all the fruit yield and quality measurements, the maximum mean differences due to producers were twice as much to that of cultivars (28.2% and 14.1%). Some of the hybrids showed higher adaptations as represented by lower variation among producers. In order to maximize the yield of a given cultivar, seed companies need to advise producers on the specific requirements of the hybrid. Otherwise, producers are not satisfied with the cultivar's performance and tend to change to a new cultivar. Breeding and marketing companies should train producers to minimize yield and quality losses in tomato as well.

MAKALE BİLGİSİ

Alınış tarihi 07 Kasım 2016
Düzeltilme tarihi 15 Mart 2017
Kabul tarihi 28 Mart 2017

Anahtar Kelimeler:

Domates
Performans
Üretici
Sera
Çevresel varyasyon

ÖZ

Genetik kapasite ve üretim uygulamaları bitkilerin verim ve meyve kalite kriterlerini etkilemektedir. Bu çalışmanın amacı hibrit domates çeşitlerinin ve üreticilerin verim ve kalite kriterleri üzerine etkileri belirlemektir. Bitki materyali olarak 5 ticari hibrit domates çeşidi kullanılmıştır (Yeliz, Lamia, 7806, Asil ve Mira). Bitkiler Antalya, Türkiye’de 12 farklı üretici serasında 2013-2014’de günlük üretim sezonunda (ağustos-mart) yetiştirilmiştir. Hem çeşit hem de üretici etkisi önemli bulunmuştur ($p < 0.05$). Üretici faktörünün incelenen tüm kriterlerdeki, maksimum farklar ortalaması çeşit faktörünün yaklaşık 2 katı olarak (% 14.1 ve % 28.2) gerçekleşmiştir. Üreticiler arasında bazı hibrit çeşitler düşük varyasyon ile yüksek adaptasyon göstermiştir. Çeşitlerin verimini en üst düzeye çıkarmak için, tohum şirketleri üreticilere hibrit domateslerin çok özel gereksinimleri konusunda tavsiyeler vermelidir. Aksi durumda, üreticiler çeşidin performansından memnun olmayarak ve yeni bir çeşit için çeşitlerini değiştirme eğilimindedirler. İslah ve pazarlama şirketleri, domates ürünlerinin verim ve kalite kayıplarını en aza indirmek için üreticileri eğitmelidir.

1. Introduction

Genetics and production practices determine yield and quality of tomato fruit (Sacks and Francis 2001; Gomez et al. 2001; Martinez-Valverde et al. 2002; Lenucci et al. 2006; Tigist 2013). Most breeding and marketing companies aid their producers on the specifics of agronomic requirements of the hybrid cultivars to achieve an optimum performance. However, these attributes may be adversely affected by conditions created by producers. Tomato growers usually change the cultivars when yield/profits fall below their expectations. It is observed that the growers obtaining below average yield tend to change cultivars the most often. This hinders those finding real solutions to their problem, failing to improve production practices.

In the regions where producers change cultivars frequently, impacts of cultivar and conditions of producers on the yield and quality of tomato were studied to make informed decisions.

There are a number of the studies focusing on the impact of the cultivars on yield and quality of crops (Gawad et al. 2005; Zaller 2007; Tigist 2013; Budak and Erdal 2016). The purpose of this study was to comparatively measure the impact and variation of cultivars and producers on the yield and quality of tomato grown by 12 different producers/greenhouses in the fall, in the central region Antalya, Turkey. The results may contribute to the cultivar selection strategies and facilitate farmer training programs in the region.

2. Materials and Methods

In the study, Yeliz (Semini seed co., US), Lamia (Hazera seed co., IL), 7806 (Semini seed co., US), Asil (Bircan seed co., TR) and Mira (Bircan seed co., TR) hybrid tomato cultivars, suitable for fall season and cultivated widely in Antalya region, were used as plant materials. The study was carried out between August 2013 and March 2014 in 12 different producers' greenhouses. Each producers planted 36 seedlings from each cultivar, 12 plants per replication and center 10 plants were used in data collections. Plantings were made 100 cm x 40 cm; the first harvest was on 23rd October 2013. Tomato was harvested 9 times in each producer greenhouse throughout the season. Fruits sampled from the 5th harvest from each producer were used for detailed analyses.

2.1. Calculation of the highest - lowest differential of the impact of cultivars and producers

Cultivars and Producers influence maximum difference = (Max. value - Min. value) / Max. value.

2.2. Total yield per plant

The fruits from each harvest were measured with a digital caliper (Mitutoyo, Digimatic, CN). They were classified as 1st quality (≥ 56 mm in diameter) or 2nd quality if smaller, cracked, and lacking desired color. Then, fruit yields for each quality classes were calculated (kg plant^{-1}) (Table 1 and 2).

2.3. Fruit measurements

The ten fruits randomly sampled from each harvest for each cultivar and producers were weighted, then, fruit weights (g fruit^{-1}) were determined (Table 1 and 2). Similarly, the fruit diameter was measured by a digital caliper (Mitutoyo, Digimatic, CN) and averaged for each cultivar/producer (Table 1 and 2).

2.4. Total soluble solids (TSS)

Five fruits were randomly samples representing each cultivar/producer on the 5th harvest were subjected to TSS measurement. The fruits were squeezed by a fruit press (Pro 120, Moulinex, FR), and juice was filtered through a rough filter paper. The amount of TSS was measured with a refractometer (Model Number REF121, Atago, CN) (Table 1 and 2, and the results were expressed as percent dry matter (Dogan et al. 2016).

2.5. Fruit firmness

Firmness was measured using a hand-held penetrometer (Digital Force Gauge, Chatillon 20755, Florida, USA) equipped with a conical probe (7.9 mm in diameter), measuring the peeled equatorial surface on 3 sides of the fruit. The results were expressed as kg cm^{-2} . For each test, ten fruit with 3 replications were used (Cemeroğlu et al. 2007) (Table 1 and 2).

2.6. Fruit color

External skin color (three measurements at three equidistant points on the equatorial region of each individual fruit) was measured on ten fruit from each replicate using a color meter (CR 200, Minolta, Ramsey, NJ, USA) and recording CIE L^* , a^* , and b^* values. Negative a^* values were indicated green and positive a^* values red color. Higher positive b^* values were

indicated a more yellow skin color and negative b^* blue color. These values were then used to calculate hue angle, where $0^\circ = \text{red-purple}$; $90^\circ = \text{yellow}$; $180^\circ = \text{bluish green}$; and $270^\circ = \text{blue}$ (McGuire 1992), and Chroma, which indicates the intensity or color saturation (Table 1 vs 2).

$$C = \sqrt{a^{*2} + b^{*2}} \quad h^{\circ} = \arctan \frac{a^*}{b^*}$$

2.7. Statistical analysis methods

The five different hybrid tomato cultivars were grown in 12 greenhouses in the fall production season. In a randomized complete block design, the 12 greenhouses were used to calculate producers effect, and the cultivars as blocks. The data was analyzed using MINITAB-16 statistics software (Minitab Inc., US) and Tukey was used to separate the means ($p < 0.05$).

3. Results and Discussion

The effects of cultivar and producer, 1st and 2nd quality fruit yields; fruit weight, diameter, firmness, TSS, L, C* and h° values, were all significant ($p < 0.05$). Results showed that cultivar (Zorzoli et al. 2000; Rehman et al. 2000; Thompson et al. 2000; Hussain et al. 2001; Sacks and Francis 2001; Gomez et al. 2001; Martinez-Valverde et al 2002; Wold et al. 2004; Krauss et al. 2006; Lenucci et al. 2006; Satesh et al 2007; Jones 2008; Cemeroğlu et al. 2009; Sharma et al. 2009; Dar and Sharma 2011; Helyes et al. 2014) and producer had substantial influence on the yields (Table 1 and 2). The percent differences in the yield of first-quality fruit were 13.8% and 51.1% due to cultivar and producer effects, respectively (Table 3). There were similar trend for 2nd quality fruit yields (Table 3). The effect of producer on the yield were about four times higher than cultivar. The cultivar Yeliz F1 had the highest first-quality fruit yield ($3.70 \text{ kg plant}^{-1}$), while the Asil F1, with the lowest standard deviation (± 0.17) (Table 1), showed the highest adaptation, an important factor when deciding to a new cultivar.

Similarly, both cultivar (14.0%) and producer (12.5%) had significant effect on the fruit weight (Table 3). The Mira F1 yielded the largest fruit ($161.9 \text{ g fruit}^{-1}$) while Lamia F1 exhibited the lowest variation (± 1.64) among the hybrids (Table 1). The fruit diameter also varied due to cultivar (3.3%) and producer (5.3%) (Table 3). The effect of producer on TSS was two-fold higher than that of cultivar (19.6 vs 10.8%) (Table 3). The Lamia F1 had the highest average TSS (4.25%), and the 7806 F1 the lowest variation (± 0.04) (Table 1).

Producers caused about 50% variation on fruit firmness, twice that of cultivars with 25% (Table 3). The Mira F1 exhibited the highest firmness and the Lamia F1 the lowest variation (± 0.18) (Table 1). Production practices (irrigation, fertilization, etc.) can dramatically improve or worsen the fruit firmness, hence shelf life of fruits.

The L^* value is a measure of the lightness of the sample, the C^* value describes its brightness while the h° value represents true color (Selçuk and Erkan 2015; Topcu et al. 2015). The color is one of the most important factors during marketing of fruit and vegetables. The maximum differences due to cultivar and producers were 2.3% and 10.0% on L^* value, 11.4% and 16.6% C^* value, 5.6% and 31% for hue angle, respectively (Table 3). Results indicate that production practices may have a large effect on the color of harvested fruit. The Asil F1 and Mira F1 possessed the highest L^* (42.99) while the Lamia the

Table 1. The effects of cultivars on fruit yield and quality criteria.

Cultivars	Yield kg plant ⁻¹		Fruit Weight g fruit ⁻¹	Fruit Diameter mm fruit ⁻¹	TSS %	Fruit Firmness kg cm ⁻²	Fruit Color		
	1. Quality	2. Quality					L	C*	h°
Yeliz	3.70±0.23 ^a	0.92±0.08 ^a	139.27±2.51 ^c	70.98±0.54 ^{bc}	3.79±0.13 ^b	2.70±0.22 ^b	42.15±0.41 ^b	27.57±0.72 ^b	50.84±1.66 ^a
Lamia	3.59±0.26 ^{ab}	0.82±0.13 ^a	139.95±1.64 ^c	70.56±0.31 ^c	4.25±0.11 ^a	2.75±0.18 ^b	41.99±0.37 ^b	30.34±0.55 ^a	49.58±1.69 ^{ab}
7806	3.50±0.21 ^{ab}	0.73±0.05 ^{ab}	152.28±2.85 ^b	72.17±0.48 ^{ab}	3.85±0.04 ^b	3.15±0.30 ^{ab}	42.65±0.38 ^{ab}	31.12±0.56 ^a	48.04±1.60 ^b
Asil	3.19±0.17 ^b	0.55±0.04 ^b	143.48±2.29 ^c	71.61±0.38 ^{bc}	3.87±0.07 ^b	3.02±0.21 ^b	42.99±0.50 ^a	30.07±0.54 ^a	50.89±1.77 ^a
Mira	3.28±0.21 ^{ab}	0.55±0.07 ^b	161.87±3.72 ^a	73.07±0.52 ^a	4.01±0.09 ^{ab}	3.60±0.23 ^a	42.99±0.41 ^a	30.47±0.65 ^a	50.51±1.79 ^a
Min.	3.19±0.17^b	0.55±0.04^b	139.27±2.51^c	70.56±0.31^c	3.79±0.13^b	2.70±0.22^b	41.99±0.37^b	27.57±0.72^b	48.04±1.60^b
Max.	3.70±0.23^a	0.92±0.13^a	161.87±3.72^a	73.07±0.52^a	4.25±0.11^a	3.60±0.23^a	42.99±0.41^a	31.12±0.56^a	50.89±1.77^a

*The differentials between the values not shown by the same letter are significant on 5% level.

Table 2. The effect of producers on fruit yield and fruit quality criteria.

Producers	Yield kg plant ⁻¹		Fruit Weight g fruit ⁻¹	Fruit Diameter mm fruit ⁻¹	TSS %	Fruit Firmness kg cm ⁻²	Fruit Color		
	1. Quality	2. Quality					L	C*	h°
1	3.03±0.23 ^{def}	0.96±0.16 ^{ab}	157.43±4.39 ^a	72.86±0.37 ^{ab}	3.76±0.17 ^{bc}	3.72±0.38 ^{ab}	42.30±0.28 ^c	32.81±0.72 ^a	45.06±0.64 ^{de}
2	3.76±0.27 ^{abcd}	1.18±0.21 ^a	144.70±6.01 ^{abc}	70.68±0.57 ^{bc}	3.98±0.08 ^{abc}	4.42±0.25 ^a	41.95±0.36 ^{cde}	29.76±2.01 ^{abc}	49.74±0.75 ^c
3	2.51±0.16 ^{ef}	0.65±0.06 ^{abc}	137.78±2.11 ^c	70.18±0.27 ^c	3.54±0.14 ^c	2.42±0.26 ^{cd}	43.21±0.56 ^{bc}	29.74±0.72 ^{abc}	54.49±1.98 ^{ab}
4	3.15±0.16 ^{cde}	0.48±0.03 ^c	152.30±4.98 ^{ab}	73.76±0.65 ^a	3.88±0.08 ^{abc}	3.64±0.30 ^{ab}	40.56±0.19 ^e	32.56±0.41 ^a	41.83±0.56 ^{ef}
5	3.49±0.19 ^{bcd}	0.63±0.05 ^c	149.14±4.07 ^{abc}	72.16±0.62 ^{abc}	4.02±0.09 ^{ab}	2.30±0.18 ^d	42.47±0.36 ^c	29.39±0.35 ^{abc}	48.90±0.62 ^{cd}
6	2.20±0.12 ^f	0.52±0.05 ^c	137.99±2.98 ^c	69.89±0.61 ^c	4.18±0.18 ^{ab}	2.45±0.33 ^{cd}	42.38±0.34 ^c	27.36±0.89 ^c	52.69±0.82 ^{bc}
7	3.50±0.24 ^{bcd}	0.71±0.07 ^{abc}	138.49±2.40 ^{bc}	70.57±0.25 ^{bc}	4.40±0.17 ^a	3.06±0.05 ^{bcd}	40.74±0.10 ^{de}	31.66±1.02 ^{ab}	39.85±0.87 ^f
8	4.50±0.22 ^a	0.60±0.14 ^{bc}	157.26±6.27 ^a	72.99±0.78 ^{ab}	3.92±0.10 ^{abc}	3.23±0.28 ^{bc}	42.60±0.30 ^c	30.09±0.88 ^{abc}	49.22±1.04 ^{cd}
9	4.18±0.23 ^{ab}	0.63±0.10 ^{bc}	153.68±7.47 ^a	71.43±0.91 ^{abc}	4.26±0.19 ^{ab}	3.70±0.23 ^{ab}	43.25±0.17 ^{bc}	28.82±0.44 ^{bc}	54.61±1.02 ^{ab}
10	3.99±0.14 ^{abc}	0.60±0.15 ^{bc}	150.29±6.67 ^{abc}	72.65±0.97 ^{ab}	3.86±0.09 ^{bc}	2.53±0.16 ^{cd}	45.07±0.19 ^a	28.21±0.31 ^c	56.50±0.75 ^{ab}
11	3.49±0.23 ^{bcd}	0.75±0.10 ^{abc}	144.03±6.70 ^{abc}	71.44±0.77 ^{abc}	3.86±0.01 ^{bc}	2.27±0.08 ^d	42.13±0.30 ^{cd}	29.91±0.73 ^{abc}	49.12±1.33 ^{cd}
12	3.61±0.11 ^{abcd}	0.82±0.14 ^{abc}	145.34±4.57 ^{abc}	71.54±0.58 ^{abc}	3.78±0.09 ^{bc}	2.77±0.16 ^{bcd}	44.53±0.53 ^{ab}	28.66±0.33 ^{bc}	57.75±0.89 ^a
Min.	2.20±0.12^f	0.48±0.03^c	137.78±2.11^c	69.89±0.61^c	3.54±0.14^c	2.27±0.08^d	40.56±0.19^e	27.36±0.89^c	39.85±0.87^f
Max.	4.50±0.22^a	1.18±0.21^a	157.43±4.39^a	73.76±0.65^a	4.40±0.17^a	4.42±0.25^a	45.07±0.19^a	32.81±0.72^a	57.75±0.89^a

*The differentials between the values not shown by the same letter are significant on 5% level.

Table 3. Cultivars and producer effect maximum differential on fruit yield and fruit quality criteria.

Differential effect	Yield		Fruit Weight (%)	Fruit Diameter (%)	TSS (%)	Fruit Firmness (%)	Fruit Color			Mean (%)
	1. Quality (%)	2. Quality (%)					L (%)	C* (%)	h° (%)	
Cultivars	13.8	40.2	14.0	3.3	10.8	25.0	2.3	11.4	5.6	14.1
Producers	51.1	59.3	12.5	5.3	19.6	48.6	10.0	16.6	31.0	28.2

lowest variation (±0.37). The 7806 F1 possessed the highest C* (31.12) while the Asil F1 the lowest variation (±0.54) (Table 1). The Asil F1 possessed the highest hue angle (50.89) while the 7806 the lowest variation (±1.60).

4. Conclusion

The genetic make up of a given hybrid determined half of the variation to that of the producer. However, the degree of difference varied among measurements, which was highest for 1st quality fruit by 51.1% caused by producers effect. The differences for 2nd quality fruits were the highest (59.3% vs 40.2%) due to producers and cultivars, respectively. This result show that 2nd quality fruit can be decreased in favor of 1st quality yield by both genetic improvement and better production practices. Some of producers tend to grow hybrids with high genetic capacity. However, other producers usually fail to get expected yield and quality, hence the profit, and change cultivar they grow more often. Hybrids with high environmental adaptation should be promoted for such producers to reduce yield and quality losses. Determining which performance is important for producers and how important it is for the cultivar

selection strategy of the manufacturer. This assessment also produces beneficial results in terms of which of the marketing proposals may or may not be right for the manufacturers. Seed breeding and marketing companies are considered to have performed these evaluations. However, in the sales phase, these results are not transferred sufficiently to producers, and producers often turn to variety because they can't choose the right varieties for their conditions and applications. Very frequent changing in cultivars may delay the focus on producers' inadequacies and application failure due to producers' preferences.

Acknowledgment

The authors would like to express their appreciation to the Scientific Fund of Akdeniz University (Project of Master Thesis) (Project No: 2013.02.0121.019).

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