



## Agronomic Performance of Different Sweet Corn Varieties in the Highest Plain of Turkey: Quality Characteristics\*

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doi: 10.17097/ataunizfd.680520

Geliş Tarihi (Received): 28.01.2020 Kabul Tarihi (Accepted): 26.06.2020 Yayın Tarihi (Published): 25.09.2020

**ABSTRACT:** Sweet corn is produced for human consumption and its grain quality primarily depends on the genotype. This study was carried out during the 2017 and 2018 seasons, in order to determine the suitable sweet corn varieties for Erzurum, Turkey. A randomized complete block design was used. Ear length (EL), ear diameter (ED), ear weight (EW), 1000-kernel weight (TKW), soluble solid content (SSC), crude protein content (CPC), and grain moisture content (GMC) of the 11 sweet corn varieties were investigated. Significant differences were determined among the varieties in terms of the investigated traits. The highest EL obtained from Khan F<sub>1</sub> (19.8 cm), ED from Baron F<sub>1</sub> (50.5 mm), EW from Baron F<sub>1</sub> (323.5 g), TKW from Signet (358.8 g), SSC at harvest from Tanem F<sub>1</sub> (20.3%), and CPC from BATEM Tatlı (16.5 %). At seven days post-harvest, the lowest reductions in grain moisture content were determined in Baron F<sub>1</sub> both in the field and refrigerator conditions. The lowest losses in SSC both in the field and refrigerator conditions were determined in Khan F<sub>1</sub>. Based on the results of the two-year research in terms of all the quality traits, Tanem F<sub>1</sub> variety can be the first choice for the production for fresh consumption in the Erzurum region.

**Keywords:** Sweet corn, Variety, Quality, Protein, Soluble solid

### Türkiye'nin En Yüksek Ovasında Tatlı Mısır Çeşitlerinin Agronomik Performansı: Kalite Karakterleri

**ÖZ:** Tatlı mısır insan gıdası için üretilir ve tane kalitesi başlıca genotipe bağlıdır. Bu çalışma Erzurum/Türkiye için uygun tatlı mısır çeşitlerini belirlemek amacıyla 2017 ve 2018 sezonlarında tesadüf blokları deneme desenine göre yürütülmüştür. Tatlı mısır çeşitlerinin koçan uzunluğu, koçan çapı, koçan ağırlığı, bin tane ağırlığı, suda çözünür kuru madde oranı, ham protein oranı ve tane nem oranı incelenmiştir. İncelenen özellikler yönünden çeşitler arasında önemli farklar olduğu belirlenmiştir. En yüksek koçan uzunluğu Khan F<sub>1</sub> (19.8 cm), koçan çapı Baron F<sub>1</sub> (50.5 mm), koçan ağırlığı Baron F<sub>1</sub> (323.5 g), 1000-tane ağırlığı Signet (358.8 g), suda çözünür kuru madde oranı Tanem F<sub>1</sub> (% 20.3) ve ham protein oranı ise BATEM Tatlı (% 16.5) çeşitlerinden elde edilmiştir. Hasat sonrası yedinci günde, tarla ve buzdolabı koşullarında tane nem içeriğindeki azalma en az Baron F<sub>1</sub>, suda çözünür kuru madde içeriğindeki azalma en az Khan F<sub>1</sub> çeşidinde olmuştur. İki yıllık çalışmanın kalite özelliklerine ait sonuçlar esas alındığında Erzurum yöresinde taze tüketim amacıyla kaliteli tatlı mısır üretimi için Tanem F<sub>1</sub> çeşidi tercih edilebilir.

**Anahtar Kelimeler:** Tatlı mısır, Çeşit, Kalite, Protein, Suda çözünür kuru madde

### INTRODUCTION

The use of sweet corn (*Zea mays* L. *saccharata* Sturt.) as human food and its economic value is constantly increasing. The main characteristic of sweet corn is that its endosperm has a high sugar content, which is protected from changing into starch by at least

one of the eight recessive gene. Base on the average kernel's sugar content; sweet corn is grouped into three major genetic groups, standard (*su1*), sugary enhanced (*se1*) and super sweet (*sh2*) (Okumura et al., 2013). Sweet corn ears during harvest at milk stage for human

**Bu makaleye atıfta bulunmak için / To cite this article:** Stanluos, A.A.L., Öztürk, A., Kodaz, S., 2020. Agronomic Performance of Different Sweet Corn Varieties in the Highest Plain of Turkey: Quality Characteristics. Atatürk Univ. J. of Agricultural Faculty, 51 (3): 249-257. doi: 10.17097/ataunizfd.680520

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\*This study is a part of the Atom Atanasio Ladu STANLUOS's master thesis accepted by Atatürk University, Graduate School of Natural and Applied Sciences, Department of Field Crops in 2018.

diet as fresh, conserve or even as proceed food according to its groups has a high sugar content, protein, oil and vitamins (A, B, C, E and K) also it contains some nutrient elements like Ca, K, Fe, Na and Zn (Oktem 2008; Sonmez et al., 2013).

Sweet corn can differ according to its quality traits uses for fresh consumption the ears should be dough with a high marketable ear yield; conserved and freezes for industrial products, the kernels should contain high weight, sugar content and yellow kernels are the most wanted (Basciftci et al., 2012). Marketable ear of sweet corn at harvest must contain 69-75% moisture, at least 15 cm ear length, 3 cm diameter and at least 14 kernels per row (Okumura et al., 2013). In sweet corn production, 1000 kernels weight and quality are important especially varieties with high kernel weight are preferred (Khazaei et al., 2010). Standard sweet corn's sugar content at harvest is 4-6% and during storage in the refrigerator its sugar change to starch faster compered to sugary enhanced group 6-8% sugar content. Super sweet group with 8-12% sugar content; moisture loss and change of sugar into starch is slower and its storage duration is longer (Azanza et al. 1996; Szymanek et al., 2006). Goldman and Tracy (1994) stated that the average protein content in sweet corn super sweet group varieties (17.6%) is higher than the one of standard sweet corn group varieties (13.5%). Related to the delay of harvesting time/date; kernel's moisture content, total soluble solids reduced whereas starch, dry matter, 1000 kernels weight and protein content increases (Szymanek, 2009; Kantarci et al., 2016).

In order to increase sweet corn production, high yield and high quality varieties suitable for each region should be determined. In this research, 11 sweet corn varieties were tested in Erzurum Plain conditions and some quality characteristics were investigated.

## MATERIAL AND METHOD

The 11 sweet corn varieties were grown in Erzurum, Turkey in 2017 and 2018 years. The plants were harvested manually when kernel moisture content reached 73 ±1%. The yield of marketable ears of varieties was found between 3205.0-16858.3 kg ha<sup>-1</sup>, the number of marketable ears per hectare was between 12611.1-66944.5 and fresh kernel yield was between 1681.5-11855.0 kg ha<sup>-1</sup>. Genetic groups and the other agronomic traits of the varieties used in these experiments, details of the environments and experimental design were presented in the previous paper (Stansluos et al., 2020). In this research, 10 marketable unhusked ears (with ears above 15 cm of

length and 30 mm of diameter) (Okumura et al. 2013) for each plot were randomly selected to measure the ear length, ear diameter and ear weight. Fresh kernel weight was determined from 4 x 100 randomly selected whole kernel samples. The soluble solid content (SSC) was measured by using a digital handrefraktometer (KRÜSS Model DR201-95) and expressed degree brix (°Brix). This procedure was done for the fresh kernels samples immediately after harvest, in kernels of husked ears which were stored in the refrigerator for seven days and in kernels of ears whose harvest date was delayed seven days. Grain nitrogen content was determined by using the micro Kjeldahl apparatus and multiplied by the converting factor (6.25) to get grain protein content (Alan et al., 2014). Moisture content in kernels of the ears which stored in the refrigerator for seven days and harvest date was delayed seven days was measured according to the ASAE (1983) method of drying in the oven at 103 °C for 72 h (Szymanek et al., 2015).

Statistical Analysis System (SAS 9.0) software program was used to determine the variance analysis and the differences among the varieties were tested using Duncan multiple comparison tests in accordance with the experimental design (RCBD). Data were combined over the years and presented as a 2-year mean values.

## RESULTS AND DISCUSSION

In 2017, temperatures were higher than that in 2018 and long-term mean, but total rainfall during corn growing season (from May to September) was lower. The results of the analysis of variance showed that most of the quality traits (except ear weight and 1000-kernel weight) were significantly influenced by experiment years. Higher rainfall amount during the growth cycle in 2018 increased ear length and ear diameter, but decreased soluble solid content and crude protein content. The variety factor had a highly significant effect on all the quality traits studied. Except for ear length and grain moisture content, year x genotype interactions were significant for the investigated traits (Tables 1, 2).

### Ear length and ear diameter

The ear lengths of the varieties varied between 16.1 and 19.8 cm. The longest ear was determined in Khan F<sub>1</sub> cultivar and Argos. The varieties with the shortest ear length were BATEM Tatlı and Kompozit Şeker (Table 1). The ear length, which is controlled by the genetic and environmental factors, is positively affecting the number of kernels, kernel yield and the

marketing value of the ear as a yield factor in sweet corn production (Sonmez et al., 2013). In previous the researches, it was determined that there were significant differences between sweet corn varieties in terms of ear length. The values obtained from this study, showed proximity to the values obtained under İzmir conditions 13.0-19.8 cm (Esiyok and Bozokalfa, 2005), however, the determined in Harran Plain conditions 17.3-23.3 cm (Oktem and Oktem, 2006), in Eskişehir conditions 21.9-23.8 cm (Sonmez et al., 2013) and in Slovakia conditions 18.5-22.0 cm (Baratova et al., 2016) higher than our values. This result may be the genetic structure of the varieties, as

well as the environmental conditions and cultivation techniques of the research site. Indeed, the ear length is significantly influenced by sowing date (Turgut and Balci, 2002), insufficient moisture conditions (Farsiani et al., 2011; Ertek and Kara, 2013) and high plant density is decreased, whereas it increased in a high nitrogen dose (Turgut, 2000).

The ear diameter of the sweet corn varieties was determined between 42.8-50.5 mm. The largest ear diameter was obtained from Baron F<sub>1</sub> and Signet varieties; while the narrowest ear diameter was determined from BATEM Tatlı and Kompozit Şeker (Table 1).

**Table 1.** Mean values of sweet corn varieties for ear length, ear diameter, ear weight, 1000-kernel weight and soluble solid content<sup>1</sup>

Varieties	Ear length (cm)	Ear diameter (mm)	Ear weight (g)	1000-kernel weight (g)	Soluble solid content (%)
Argos	19.3 <sup>ab</sup>	49.1 <sup>abc</sup>	257.0 <sup>b</sup>	332.6 <sup>bc</sup>	14.1 <sup>c</sup>
Baron F <sub>1</sub>	17.5 <sup>e</sup>	50.5 <sup>a</sup>	323.5 <sup>a</sup>	323.1 <sup>bcd</sup>	14.2 <sup>c</sup>
BATEM Tatlı	16.1 <sup>f</sup>	42.8 <sup>e</sup>	168.4 <sup>d</sup>	310.3 <sup>cde</sup>	18.5 <sup>b</sup>
Challenger	18.8 <sup>bc</sup>	45.9 <sup>d</sup>	242.2 <sup>bc</sup>	325.4 <sup>bcd</sup>	13.9 <sup>c</sup>
Febris	18.5 <sup>cd</sup>	47.7 <sup>c</sup>	256.6 <sup>b</sup>	284.6 <sup>f</sup>	14.1 <sup>c</sup>
Khan F <sub>1</sub>	19.8 <sup>a</sup>	47.9 <sup>bc</sup>	261.4 <sup>b</sup>	323.9 <sup>def</sup>	13.5 <sup>c</sup>
Kompozit Şeker	16.2 <sup>f</sup>	44.8 <sup>d</sup>	206.1 <sup>cd</sup>	328.9 <sup>bcd</sup>	17.4 <sup>b</sup>
Overland	18.0 <sup>cde</sup>	48.1 <sup>bc</sup>	257.4 <sup>b</sup>	306.4 <sup>def</sup>	13.4 <sup>c</sup>
SHY1036	17.8 <sup>de</sup>	49.4 <sup>ab</sup>	262.9 <sup>b</sup>	289.6 <sup>ef</sup>	13.8 <sup>c</sup>
Signet	18.7 <sup>bc</sup>	50.4 <sup>a</sup>	287.0 <sup>ab</sup>	358.8 <sup>a</sup>	13.8 <sup>c</sup>
Tanem F <sub>1</sub>	18.1 <sup>cde</sup>	47.6 <sup>c</sup>	250.3 <sup>bc</sup>	336.1 <sup>b</sup>	20.3 <sup>a</sup>
Mean	18.1	47.7	252.1	320.0	15.2
2017	17.9	47.1	249.1	318.5	16.3
2018	18.2	48.3	255.1	321.5	14.0
F value (Year)	4.85*	8.77**	0.44	0.50	69.22***
F value (Variety)	20.43***	15.59***	7.18***	9.14***	25.25***
F value (YxV)	2.07	5.02***	2.40*	5.78***	2.75**
CV (%)	3.48	2.55	14.43	5.38	7.65

<sup>1</sup> The means marked with the same letter are not different from each other. F values marked with \*, \*\* and \*\*\* are significant at the probability levels of 0.05, 0.01 and 0.001, respectively.

Ear diameter under the influence of genotypes and environment is an important characteristic affecting the number of kernel rows per ear and the number of kernels per ear, the kernel yield and the marketing value of the ear (Sonmez et al., 2013). However, a

numerous researches on the subject; it was noted that there was a significant difference between the varieties of sweet corn in terms of ear diameter (Oktem and Oktem, 2006; Sonmez et al., 2013). According to researches done on sweet corn, the effect of sowing

date (Oktem et al. 2004), irrigation (Farsiani et al., 2011; Ertek and Kara, 2013), and plant geometry and nitrogen dose (Turgut, 2000) was determined significantly. Thus, according to the varieties the ear diameter was varied significantly in Izmir conditions 41.0-43.0 mm (Esiyok and Bozokalfa, 2005), in Şanlıurfa conditions 37.9-47.6 mm (Oktem and Oktem, 2006), in Eskisehir conditions 48.0-54.1 mm (Sonmez et al., 2013), in the USA conditions the values was between 44.7-50.0 mm (Maynard and Bluhm, 2017) which are close to our findings.

### Ear weight and 1000-kernel weight

Ear weight as well as its quality is an important factor in sweet corn cultivation and it is the criterion, which affects marketing and price of sweet corn ears. According to Oktem and Oktem (2006), consumers prefer ears with a long and wide diameter. Under Erzurum ecological conditions, the ear weight of the varieties was determined between 168.4 and 323.5 g. The highest ear weight was obtained from Baron F<sub>1</sub> and Signet whereas the lowest ear weight was determined in BATEM Tatlı and Kompozit Şeker (Table 1). In aspect of ear weight, related to the genetic structure a significant variation was determined in the previous researches. According to varieties, variation in fresh ear weight was determined in Bursa conditions between 180.7-193.9 g (Turgut and Balci, 2002), in Şanlıurfa conditions 167.8-251.7 g (Oktem, 2008), in Eskişehir conditions 338.0-406.0 g (Sonmez et al., 2013), in Slovakia conditions 183.0-269.5 g (Baratova et al., 2016), in the USA conditions 283.5-427.5 g (Maynard and Bluhm, 2017). Fresh ear weight also may vary according to sowing date (Oktem et al., 2004), locations (Esiyok et al., 2004), irrigation techniques (Ertek and Kara, 2013), plant geometry, plant density and nitrogen doses (Turgut, 2000; Thakur et al., 2015).

The 1000-kernel weights of the sweet corn varieties in this research ranged between 284.6-358.8 g. The highest weight of the thousand kernels determined by Signet and Tanem F<sub>1</sub> while the lowest was obtained by Febris and SHY1036 (Table 1). The weight of the 1000-kernel in sweet corn production, yield and quality are an important element, especially in the production for canned purposes high kernel weight is the reason of variety selection (Khazaei et al., 2010). In the previous studies, a significant difference among the varieties of sweet corn was observed in terms of 1000-kernel weight. However, in some researches based on fresh and dry grain weight, the results of harvest date and cultural practices differences was difficult to evaluate. In this study, based on the fresh weight values of the

varieties were approximately close to the one was determined by Znidarcic et al. (2008) 234.1-340.5 g and by Oladeji et al. (2014) 240.0-356.0 g. Due to the limiting effect of the *sh2* gene starch synthesis, the kernel weight in super-sweet is lower than the standard varieties (Goldman and Tracy, 1994). In this study, also the highest kernel weights were determined in standard and sugary enhanced varieties, while the lowest kernel weights were determined in super sweet varieties. Thousand kernel weight can vary according to the cultural practices; plant density, nitrogen dose and, irrigation conditions significantly affected the weight of kernels (Kashiani et al., 2011; Thakur et al., 2015).

### Soluble solid content (SSC) and crude protein content

The soluble solid contents of the sweet corn varieties ranged from 13.4 to 20.3% (Table 1). The highest value was obtained by Tanem F<sub>1</sub> and BATEM Tatlı. These varieties were found to be significantly superior to the other varieties. The lowest SSC was measured from Overland and Khan F<sub>1</sub> (Table 1). In sweet corn, the sweetness of the kernel is the most important element of the meal quality and sucrose content is regulated by carbohydrate metabolism in kernel filling period. In addition to that, varieties with high sugar content endosperm have been developed by the reduction of starch synthesis activities and increasing sucrose accumulation (Szymanek et al., 2015). As the total soluble solid forms the majority of the sugars, in the comparison of the sweetness, the SSC is used as a criterion (Khanduri et al., 2011; Basciftci et al., 2012). In fact, in conditions where isolation is not provided, the sugar content can vary considerably according to the fertilization status, and the sugar content specified in open pollinated varieties are not accurate (Khanduri et al., 2011). In this study, the highest SSC were determined from Tanem F<sub>1</sub> and BATEM Tatlı; which belongs to the standard sweet corn group. While the lowest SSC was obtained by Overland variety and this variety belongs to standard sweet corn group, the highest expected SSC super-sweet SHY1036, Khan F<sub>1</sub>, Argos and Baron F<sub>1</sub> varieties and the differences among these varieties were found insignificant. This may be the result of changes in the endosperm structure due to foreign/open pollination and fertilization. Khanduri et al. (2011) pointed out that the SSC that was 34.7% in controlled conditions decreased to 19.4% in open pollination conditions.

The results obtained by using refractometer are not a reliable for estimating the sugar content in sweet

corn as supported by the results of Zhu et al. (1992) and Hale et al. (2005). Based on the study conducted by Zhu et al. (1992) on the standard, sugary enhanced and super-sweet corn groups; the highest SSC was obtained from the varieties belongs to the standard

sweet corn group with low sucrose and total sugar content.

**Table 2.** Mean values of sweet corn varieties for crude protein, grain moisture content seven days post-harvest and the soluble solids content seven days post-harvest both at the field and at the refrigerator<sup>1</sup>

Varieties	Crude protein (%)	Grain moisture content seven days post-harvest (%)		Soluble solids content seven days post-harvest (%)	
		Field	Refrigerator	Field	Refrigerator
Argos	12.5 <sup>de</sup>	72.9 <sup>a</sup>	72.7 <sup>a</sup>	13.1 <sup>c</sup>	12.1 <sup>c</sup>
Baron F <sub>1</sub>	12.0 <sup>ef</sup>	71.6 <sup>ab</sup>	71.4 <sup>ab</sup>	13.2 <sup>c</sup>	12.0 <sup>c</sup>
BATEM Tatlı	16.5 <sup>a</sup>	63.6 <sup>d</sup>	62.9 <sup>e</sup>	17.2 <sup>a</sup>	14.5 <sup>b</sup>
Challenger	12.0 <sup>ef</sup>	72.8 <sup>a</sup>	72.8 <sup>a</sup>	12.2 <sup>c</sup>	11.6 <sup>c</sup>
Febris	13.2 <sup>cd</sup>	72.7 <sup>a</sup>	72.5 <sup>a</sup>	12.3 <sup>c</sup>	11.1 <sup>c</sup>
Khan F <sub>1</sub>	14.2 <sup>bc</sup>	73.2 <sup>a</sup>	72.8 <sup>a</sup>	13.3 <sup>c</sup>	11.8 <sup>c</sup>
Kompozit Şeker	14.5 <sup>b</sup>	61.9 <sup>d</sup>	60.7 <sup>e</sup>	15.5 <sup>b</sup>	13.8 <sup>b</sup>
Overland	11.3 <sup>f</sup>	68.2 <sup>c</sup>	66.3 <sup>d</sup>	12.1 <sup>c</sup>	11.0 <sup>c</sup>
SHY1036	12.7 <sup>de</sup>	71.6 <sup>ab</sup>	71.4 <sup>ab</sup>	12.8 <sup>c</sup>	11.4 <sup>c</sup>
Signet	12.0 <sup>ef</sup>	69.6 <sup>bc</sup>	69.1 <sup>bc</sup>	12.4 <sup>c</sup>	10.4 <sup>c</sup>
Tanem F <sub>1</sub>	16.0 <sup>a</sup>	70.5 <sup>b</sup>	68.8 <sup>c</sup>	18.3 <sup>a</sup>	16.0 <sup>a</sup>
Mean	13.4	69.8	69.1	13.9	12.3
2017	14.6	69.2	68.5	14.6	12.7
2018	12.1	70.4	69.7	13.1	11.9
F value (Year)	115.65***	8.93**	5.66*	27.76***	6.32***
F value (Variety)	19.38***	32.50***	31.07***	19.99***	11.37***
F value (YxV)	9.42***	0.71	0.31	2.73**	2.54*
C.V. (%)	7.13	2.37	2.65	8.53	10.05

<sup>1</sup> The means marked with the same letter are not different from each other. F values marked with \*, \*\* and \*\*\* are significant at the probability levels of 0.05, 0.01 and 0.001, respectively.

Whereas the lowest SSC was determined from super-sweet group varieties with high sucrose and total sugar content, strong and negative ( $r = -0.99$ ) relationship was determined between SSC and total sugar content. Hale et al. (2005) determined the total soluble solids contents in standard, sugary enhanced and super sweet corn varieties as 22.0-25.7%, 21.8-23.6% and 14.7-15.4%; while the total sugar content was 5.8-8.2 mg/g, 7.5-8.6 mg/g and 11.2-14.1 mg/g, respectively. The SSC of the standard sweet corn and

sugary enhanced varieties to be higher than that of super sweet varieties attract attention. The SSC in terms of normal sweet and sugary enhanced varieties was determined between 16.6-21.2% in Spain (Ordas et al., 2008), the normal and super-sweet was between 10.1-25.8% in India (Khanduri et al., 2011). In researches conducted in Turkey on sweet corn varieties; SSC varied from 12.7 to 18.6% in İzmir conditions, (Esiyok and Bozokalfa, 2005), 13.8 to 27.4% in Eskisehir conditions (Basciftci et al., 2012).

The SSC are influenced by environmental factors and cultivation techniques as well as the genetic structure. In fact, it was determined that SSC was significantly varied according to the locations (Esiyok et al., 2004) and decreased with high nitrogen doses (Sakin and Azapoglu, 2017). The sugar content of sweet corn in late sowing dates and high plant density (Burcu and Akgun, 2018), in low and high nitrogen doses (Okumura et al., 2014), with the delay of the harvest dates (Szymanek et al., 2015) decreased, and increased in water stress conditions (Farsiani et al., 2011).

The crude protein contents of the sweet corn varieties used in this research varied between 11.3 and 16.5%. The highest crude protein content was obtained from BATEM Tatlı and Tanem F<sub>1</sub> while the lowest were determined from Overland varieties (Table 2). Due to the rapid increase in sweet corn consumption, it is defined as an important source of protein and despite the different types of endosperm, information about the fresh kernel protein content of sweet corn varieties is limited (Goldman and Tracy, 1994). In a study conducted in Turkey related to the subject, crude protein content varied between 9.7 and 13.3%, the highest crude protein ratio was obtained from Challenger variety (Alan et al., 2014). The crude protein content of the same variety was determined as 18.1% in our research study. Bhargava (1983) and Liu et al. (2005) pointed out that the grain protein content of corn varieties increased in high altitude conditions. The protein content of the kernel of this research to be higher than the values determined from other research conducted in Turkey may be related to the high altitude conditions of Erzurum. In a study conducted in the USA, crude protein ratios in sweet corn varieties ranged from 11.6% to 20.5%; super sweet varieties obtained higher protein content (average 17.6%) than normal sweet varieties (average 13.5%) (Goldman and Tracy, 1994). In our study, the highest crude protein ratios were also obtained from normal sweet varieties, which is approximately similar to those reported by Goldman and Tracy (1994). The kernel quality and chemical composition of sweet corn may also be influenced by environmental conditions and cultivation techniques. The effect of nitrogen doses on the kernel protein ratio was investigated widely/extensively. In Şanlıurfa conditions the highest protein ratio (19.1%) was obtained by applying 36 kg N/da (Oktem et al. 2010), in Brazil conditions (15.2%) by applying 18 kg N/da (Okumura et al., 2014). On the other hand, it was determined that the crude protein ratio in sweet corn decreased by the of high plant density (Bhatt, 2012),

low and high irrigation levels (Ertek and Kara, 2013), early and late sowing (Burcu and Akgun, 2018).

#### **Grain moisture content and SSC seven days post-harvest**

For high-quality products, grain moisture content during the harvest date must be between 69-75% (Okumura et al., 2013). The harvest of sweet corn may not possibly made with an ideal date due to climate conditions, labour force or market conditions, and the harvested ears may not be marketed immediately at harvest date or in a short period. In Turkey, lack of common facilities where sweet corn is processed as canned and frozen products and without any loss of quality, storage challenges increases the importance of post-harvest quality losses. Moisture contents of the sweet corn varieties used in this research seven days post-harvest are between 61.9 and 73.2% under the field conditions and 60.7-72.8% in the refrigerator condition. The average of the varieties was 69.8% in the field conditions and 69.1% in the refrigerator conditions (Table 2). The highest moisture contents seven days post-harvest under the field conditions was obtained from Khan F<sub>1</sub> and Argos, while in the refrigerator conditions was from Challenger and Khan F<sub>1</sub> varieties. When compared with the moisture content during a harvest date, the average moisture content one-week post-harvest was reduced by 4.38% in the field conditions whereas it decreased by 5.34% in the refrigerator conditions. Accordingly, in order to preserve kernel moisture it may be more advantageous to delay the harvest for one week under the field conditions, instead of seven days in the refrigerator conditions. In both conditions, the lower decreases in kernel moisture content after seven days post-harvest was determined in Argos, Challenger, Febris and Khan F<sub>1</sub> varieties. Szymanek et al. (2015) found that the moisture content was 73.5, 66.4 and 60.0% in the 24<sup>th</sup>, 28<sup>th</sup> and 32<sup>nd</sup> days after pollination, respectively. Compared to these rates, the decrease in kernel moisture content due to the delay in harvest date is lower in our study. Besides the genotypic differences, this may be due to the effects of the climatic conditions after the harvest date. The moisture contents seven days post-harvest decrease in the field and the refrigerator conditions were higher in normal and sugary enhanced varieties. These results are consistent with the findings assuring that the moisture loss after harvest is the slowest in super sweet varieties, as well as its storage period is the longest (Szymanek et al., 2006).

The SSC after seven days post-harvest was between 12.1 and 18.3% in field and in the refrigerator

conditions was changed between 10.4 and 16.0% and the average SSC determined as 13.9% for field and 12.3% for refrigerator conditions. After seven days post-harvest, the highest SSC in both field and refrigerator conditions was obtained from Tanem F<sub>1</sub>; whereas the lowest SSC obtained by Overland varieties. Compared to SSC content at the harvest time (Table 1), the average SSC after seven days post-harvest was decreased by 1.31% in the field; whereas in refrigerator conditions was decreased by 2.84%. In both conditions, the minimum decrease in SSC was from Khan F<sub>1</sub> and Argos. The most important quality criteria in sweet corn production is the total soluble solid content (Dragana et al., 2013), and in order to achieve high yield and quality values, the harvesting process should be done when the kernel moisture content is 73 ±1% (Oktem et al., 2004; Okumura et al. 2013). It is essential to minimize quality losses as the conversion of sugars to starch accelerates after the harvest date or during the storage process. The rapid decline in quality after harvest limits the evaluation of the product transportation period from the production site to the market. The results of this study research showed that field conditions are more advantageous than the refrigerator conditions in terms of reducing the loss of SSC content in the kernel. Szymanek (2009) and Kantarci et al. (2016) reported that the delay in the harvest date significantly reduced the sugar content in sweet corn varieties. Baratova et al. (2016), reported that sugar content in the kernel according to the super varieties decreased between 14.8-27.4% after four days' storage in the freezer conditions. Szymanek et al. (2015), stated that the average sugar content in the kernel at 24<sup>th</sup>, 28<sup>th</sup> and 32<sup>nd</sup> days after pollination was determined by 5.5, 5.4 and 4.7% in the normal sweet varieties, respectively; 6.5, 5.2 and 4.7% in the sugary enhanced varieties; and in the super sweet varieties determined as 8.6, 7.8 and 7.2%. In order to preserve the quality of sweet corn, the most effective factor is the harvest date as reported by the researchers. They determined that the delay in harvest date lead to the highest decreased of the kernel sugar content in the sugary enhanced varieties. Khanduri et al. (2011), SSC on the 20<sup>th</sup>, 24<sup>th</sup> and 28<sup>th</sup> days after pollination measured as 16.5, 15.0 and 14.3%, respectively, and they reported that SSC response of sweet corn varieties to the harvest date and environmental factors were different.

The result of the experiments showed that select of the correct variety is a very important factor in order to achieve high quality product. In terms of 1000-kernel weight, SSC at harvest and seven days after

harvest, and crude protein content Tanem F<sub>1</sub>; ear diameter, ear weight and 1000-kernel weight Signet varieties has attracted attention for they were on the first ranks. According to the ranking by Stansluos et al. (2020), Signet and Tanem F<sub>1</sub> varieties were defined as high and moderate yields, respectively. Therefore, Tanem F<sub>1</sub> variety can be advised with high quality traits and moderate yield while Signet variety can be suggested with lower quality traits and high yield.

#### ACKNOWLEDGEMENT

This research was supported by “The Atatürk University, Scientific Research Projects Commission” (Project number: FYL-2018-6631).

#### Statement of Conflict of Interest

Authors have declared no conflict of interest.

#### Authors' Contributions

AÖ, project design, establishment of field experiments, statistical analysis, evaluation and writing of the article; AALS, establishment of field experiments, following field studies, taking observations, statistical analysis, evaluation of the study and writing the article; SK, establishment of field experiments, following field studies and taking observations, statistical analysis. All authors have read and approved the last article.

#### REFERENCES

- Alan, O., Kinaci, G., Kinaci, E., Basciftci, Z.B., Sonmez, K., Evrenosoglu, Y., Kutlu, I., 2014. Kernel quality of some sweet corn varieties in relation to processing. *Notulae Botanicae Horti Agrobotanici Cluj-Napoca*, 42 (2): 414-419.
- Azanza, F., Bar-Zur, A., Juvik, J.A., 1996. Variation in sweet corn kernel characteristics associated with stand establishment and eating quality. *Euphytica*, 87 (1): 7-18.
- Baratova, S., Slosar, M., Andrejiova, A., 2016. Examination of basic variety characteristics of sweet corn in conditions of the Southern Slovakia. *Acta Horticulturae Regiotecturae*, 19 (1): 4-7.
- Basciftci, Z.B., Alan, Ö., Kinaci, E., Kinaci, G., Kutlu, İ., Sonmez, K., Evrenosoglu, Y., 2012. Technological and quality characteristics of some sweet corn (*Zea mays saccharata* Sturt) varieties. *Selcuk Journal of Agriculture and Food Sciences*, 26 (4): 11-18. (in Turkish with abstract in English).

- Bhargava, S.C., 1983. Effect of altitude on maize protein in equatorial environment. *Indian journal of plant physiology*, 26 (3): 250-257.
- Bhatt, P.S., 2012. Response of sweet corn hybrid to varying plant densities and nitrogen levels. *African Journal of Agricultural Research*, 7 (46): 6158-6166.
- Burcu, Y., Akgun, İ., 2018. Effects of plant density and different sowing dates on fresh ear yield and quality characters of sweet corn (*Zea mays saccharata* sturt.) grown under Isparta conditions. Süleyman Demirel University, *Journal of Natural and Applied Sciences*, 22 (2): 679-684. (in Turkish with abstract in English).
- Dragana, L., Darinka, B., Berenji, J., Marinkovic, B., Crnobarac, J., Jacimovic, G., Nikolic, L., 2013. The yield and sugar content of sweet corn cultivated in organic production system. *Research Journal of Agricultural Science*, 45 (3): 117-122.
- Ertek, A., Kara, B., 2013. Yield and quality of sweet corn under deficit irrigation. *Agricultural water management*, 129: 138-144.
- Esiyok, D., Bozokalfa, M.K., Ugur, A., 2004. Determination of yield quality and some plant characteristic of some sweet corn (*Zea mays* L. var. *saccharata*) varieties in different locations. Ege University, *Journal of Agriculture Faculty*, 41 (1): 1-9. (in Turkish with abstract in English).
- Esiyok, D., Bozokalfa, M.K., 2005. The effects of sowing and planting dates on yield and some agronomic properties of sweet corn (*Zea mays* L. var. *saccharata*). Ege University, *Journal of Agriculture Faculty*, 42 (1): 35-46. (in Turkish with abstract in English).
- Farsiani, A., Ghobadi, M.E., Jalali-Honarm, S., 2011. The effect of water deficit and sowing date on yield components and seed sugar contents of sweet corn (*Zea mays* L.). *African Journal of Agricultural Research*, 6 (26): 5769-5774.
- Goldman, I.L., Tracy, W.F., 1994. Kernel protein concentration in sugary-1 and shrunken-2 sweet corn. *HortScience*, 29 (3): 209-210.
- Hale, T.A., Hassell, R.L., Phillips, T., 2005. Refractometer measurements of soluble solid concentration do not reliably predict sugar content in sweet corn. *HortTechnology*, 15 (3): 668-672.
- Kantarci, D., Pazir, F., İstipliler, D., Tosun, M., Tonk, F.A., 2016. Optimization of harvesting time by quality criteria of sweet corn. *Journal of Central Research Institute for Field Crops*, 25 (1): 70-73.
- Kashiani, P., Saleh, G., Osman, M., Habibi, D., 2011. Sweet corn yield response to alternate furrow irrigation methods under different planting densities in a semi-arid climatic condition. *African Journal of Agricultural Research*, 6 (4): 1032-1040.
- Khanduri, A., Hossain, F., Lakhera, P. C., Prasanna, B.M., 2011. Effect of harvest time on kernel sugar concentration in sweet corn. *Indian J. Genet.*, 71 (3): 1-4.
- Khazaei, F., Alikhani, M.A., Yari, L., Khandan, A., 2010. Study the correlation, regression and path coefficient analysis in sweet corn (*Zea mays* var. *saccharata*) under different levels of plant density and nitrogen rate. *Journal of Agricultural and Biological Science*, 5 (6): 14-19.
- Liu, S.Y., Dong, S.T., Hu, C.H., 2005. The study of latitude and altitude affecting to maize quality. *J. Maize Sci.*, 13 (2): 68–71.
- Maynard, E.T., Bluhm, E.A., 2017. Sugar-enhanced and synergistic sweet corn cultivar evaluation for Northern Indiana. *Midwest Vegetable Trial Report for 2017*, 1-7.
- Oktem, A., Oktem, A.G., Coskun, Y., 2004. Determination of sowing sates of sweet corn (*Zea mays* L. *saccharata* Sturt.) under Şanlıurfa conditions. *Turkish Journal of Agriculture and Forestry*, 28 (2): 83-91.
- Oktem, A., Oktem, A.G., 2006. Determination of yield characteristics of some sweet corn (*Zea mays saccharata* Sturt) genotypes under Harran Plain conditions. Uludağ University, *Journal of Agriculture Faculty*, 20 (1): 33-46. (in Turkish with abstract in English).
- Oktem, A., 2008. Effect of water shortage on yield, and protein and mineral compositions of drip-irrigated sweet corn in sustainable agricultural systems. *Agricultural Water Management*, 95 (9): 1003-1010.
- Oktem, A., Oktem, A.G., Emeklier, H.Y., 2010. Effect of nitrogen on yield and some quality parameters of sweet corn. *Communications in Soil Science and Plant Analysis*, 41 (7): 832–847.
- Okumura, R.S., de Cinque Mariano, D., Nogueira Franco, A.A., Contador Zaccheo, P.V., Ometto Zorzenoni, T., 2013. Sweet corn: Genetic aspects, agronomic and nutritional traits. *Brazilian Journal of Applied Technology for Agricultural Science*, 6 (1): 105-114.



- Okumura, R.S., Vidigal Filho, P.S., Scapim, C.A., Marques, O.J., Franco, A.A.N., Souza, R.S., Reche, D.L., 2014. Effects of nitrogen rates and timing of nitrogen topdressing applications on the nutritional and agronomic traits of sweet corn. *Journal of Food, Agriculture and Environment*, 12 (2): 391-398.
- Oladeji, A.E., Olorunfemi, O., Bussie, M.D., Abebe, M., 2014. Varietal and harvesting time effects on physical characteristics and sensory attributes of boiled fresh yellow maize hybrids. *Journal of Applied Biosciences*, 82: 7347-7358.
- Ordas, B., Revilla, P., Ordas, A., Malvar, R.A., 2008. Hybrids sugary× sugary enhancer of sweet corn: A valuable option for cool environments. *Scientia Horticulturae*, 118 (2): 111-114.
- Sakin, M. A., Azapoglu, Ö., 2017. Effects of nitrogen and phosphorous on fresh ear and grain yield with some yield and quality components of sweet corn (*Zea mays saccharata* sturt.) in Tokat-Kazova conditions. *Journal of Agricultural Faculty of Gaziosmanpasa University*, 34 (3): 46-55. (in Turkish with abstract in English).
- Sonmez, K., Alan, O., Kinaci, E., Kinaci, G., Kutlu, İ., Basciftci, Z.B., Evrenosoglu, Y., 2013. Plant, ear and yield characteristics of some sweet corn (*Zea mays saccharata* Sturt) varieties. *Journal of Agricultural Faculty of SDU*, 8 (1): 28-40. (in Turkish with abstract in English).
- Stansluos, A.A.L., Ozturk, A., Kodaz, S., 2020. Agronomic performance of different sweet corn varieties in the highest plain of Turkey: Plant growth and yields. *International Organization Science Research*, 13 (1): 13-22.
- Szymanek, M., Dobrzański, B., Niedziółka, I., Rybczyński, R., 2006. Sweet corn: harvest and technology physical properties and quality. B. Dobrzański Institute of Agrophysics Polish Academy of Sciences. Lublin.
- Szymanek, M., 2009. Influence of sweet corn harvest date on kernels quality. *Res Agr Eng*, 55 (1): 10-17.
- Szymanek, M., Tanas, W., Kassar, F.H., 2015. Kernel carbohydrates concentration in sugary-1, sugary enhanced and shrunken sweet corn kernels. *Agriculture and Agricultural Science Procedia*, 7: 260-264.
- Thakur, A.K., Thakur, D.S., Patel, R.K., Pradhan, A., Kumar, P., 2015. Effect of different plant geometry and nitrogen levels, in relation to growth characters, yield and economics on sweet corn (*Zea mays saccharata* L.) at Bastar Plateau Zone. *The Bioscan*, 10 (3): 1223-1226.
- Turgut, I., 2000. Effects of plant populations and nitrogen doses on fresh ear yield and yield components of sweet corn (*Zea mays saccharata* Sturt.) grown under Bursa conditions. *Turk. J. Agric. For.*, 24: 341-347. (in Turkish with abstract in English).
- Turgut, I., Balci, A., 2002. Effect of different sowing dates on fresh ear yield and yield components of sweet corn (*Zea mays saccharata* Sturt.) cultivars under Bursa conditions. *Uludağ University, Journal of Agriculture Faculty*, 16 (2): 79-91. (in Turkish with abstract in English).
- Zhu, S., Mount, J.R., Collins, J.L., 1992. Sugar and soluble solids changes in refrigerated sweet corn (*Zea mays* L). *Journal of Food Science*, 57 (2): 454-457.
- Znidarcic, D., Ban, D., Ilak Persuric, S.A., Bizjak Koncar, A., 2008. Yield and quality of sweet corn (*Zea mays* L. var. *saccharata*) cultivars grown on different soil types. *Cereal Research Communications*, 36: 147-150.