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Agronomic Performance of Different Sweet Corn Cultivars in the Highest Plain of Turkey: Plant Growth and Yields

Atom Atanasio Ladu Stansluos[*1] Ali Öztürk[2] Selçuk Kodaz[2]
[1]*Upper Nile University, Faculty of Agriculture, Department of Field Crops, Renk, South Sudan*
[2]*Ataturk University, Faculty of Agriculture, Department of Field Crops, Erzurum, Turkey*
Corresponding Author: Atom Atanasio Ladu Stansluos

Abstract: *Sweet corn is an attractive crop due to its high yield per unit area, short vegetation period and a good plant in crop rotation. In order to determine the suitable sweet corn varieties for Erzurum region, this research was carried out in Ataturk University Plant Production Application and Research Centre, during the 2017 and 2018 cropping seasons. Randomized complete block design was used; some traits of the varieties related to growth, yield and quality was investigated. A significant difference was determined among the varieties in terms of the investigated traits. In terms of days to silking (SD), the mean values ranged between 76.17-90.67 days, days to maturity (MD) was between 105.67-120.17 days, plant height (PH) was between 169.97-215.97 cm, number of tillers per plant (NT/P) was between 0.13-1.50, number of leaves per plant (NL/P) was between 8.92-10.95. The number of ears per plant (NE/P) was between 0.98-1.28, first ear height (FEH) was between 37.25-77.75 cm, number of plants per hectare (NP/ha) was determined between 66388.83-79166.67, dehusked ear yield (EY) was ranged between 9442.89-18790.44 kg/ha. The number of marketable ears per hectare (NME) was between 12611.06-66944.50 and the yield of marketable ears (YME) was found between 3205.00-16858.28 kg/ha. Concerning the number of kernel rows per ears (NKR/E) was between 14.12 and 18.93, number of kernels per row (NK/R) was determined between 30.77-40.33, number of kernels per ear (NK/E) was counted between 461.14-719.23, fresh kernel yield (FKY) was measured to be between 1681.50-11855.00 kg/ha; the green mass yield was determined between 35458.33 and 49406.33 kg/ha. In terms of DM, EY, yield of the fresh kernel and marketable ear Signet variety, whereas in terms of the ear yield, yield of marketable ear, and number of marketable ears Khan F_1 variety has attracted attention for they were on the first ranks. Based on the results of the combined two-year research, Signet variety can be the first suggestion for the production of sweet corn for fresh consumption in Erzurum whereas the second choice is Challenger variety.*

Keywords:*Sweet corn, variety, adaptation, yield, highest plain*

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I. Introduction

Sweet corn (*Zeamays* L. *saccharata* Sturt.) is a group of varieties that are continuously increasing economic value used as human food, animal feed and raw material in the industry. The world sweet corn cultivated area is 1125916 ha, the production is 9764006 tons and the fresh ear yield is 8670 kg/ha. Twenty-two percent of the worlds' sweet corn cultivated area and 42% of its production is covered by the USA. In Turkey, cultivated area of sweet corn is estimated by 1-2% of the total corn cultivation area [5]. In recent years, the cultivation area of sweet corn in Turkey and its economic importance are increasing, depending on the growing consumption [5]. Fresh sweet corn is an attractive alternative for consumers, as the kernel is an excellent source of vitamins C, E and B, and some minerals. Sweet corn also contains frolic acid, which has a wide range of therapeutic effects against cancer, diabetes, and cardiovascular and neurodegenerative diseases, and has antioxidant activity [51].

Corn can grow on places from the sea level up to over 2600-meter-high, from lowland altitudes to highlands [1]. Sweet corn has similar limitations to traditional corn for growth in less favorable growing conditions, with respect to cultivar's agronomic characteristics and their reactions to changes in production system in specific climatic conditions [11]. In order to produce sweet corn, it is necessary to identify the high yielding and high-quality varieties, which are suitable to the region. As well as the vegetative period of the sweet corn varieties is shorter than the one of normal corn, places with a short vegetative period, such as Erzurum can provide the opportunity for sweet corn cultivation. This research study was aiming to evaluate the performance of some sweet corn varieties in high-altitude conditions of Erzurum.

II. Material and methods

This research was carried out in Ataturk University Plant Production Application and Research Centre, during the 2017 and 2018 cropping seasons. Erzurum is located in the northeast part of Turkey, between 39º 55' north latitude and 41º 61' east longitude, it has a land with terrestrial climate, a height of 1853 m above sea level, winter is usually snowy and cold and summer is cool and dry. During this research experiment, the total rainfall was 94.0 and 285.9 mm, average temperature was 17.1 and 16.3 °C in 2017 and 2018, respectively (Table 1). Mean temperatures in were higher in comparison to long-term averages. The soil was a clay-loam with pH of 7.18-7.88, organic matter content 1.62-1.65 %, and total N content 0.088-0.094. Available P and K contents of the soils were 36.3-38.9 and 856.1-989.9 kg/ha, respectively.

Table no 1: Some climate data of Erzurum province in the research area during 2017 and 2018 with the long-term mean (LTM: 1990-2017) *

Months	Total rainfall (mm)			Average temperature (°C)			Minimum temperature (°C)		Maximum temperature (°C)	
	2017	2018	LTM	2017	2018	LTM	2017	2018	2017	2018
May	59.0	140.0	68.6	10.6	11.3	10.5	-1.1	2.3	17.9	21.8
June	12.6	76.8	43.6	15.7	14.6	14.9	1.2	3.7	24.3	30.8
July	6.8	24.8	22.8	20.8	20.1	19.2	6.0	4.2	30.6	24.4
August	15.2	33.0	16.2	21.6	19.8	19.5	4.4	6.3	31.1	32.3
September	0.4	11.3	21.3	16.7	15.5	14.0	1.2	-0.7	27.4	29.1
Total/Average	94.0	285.9	172.5	17.1	16.3	15.7				

The experiment applied using RCBD experimental design with three replications. The size of each plot was 2.5 m × 5.0 m and each plot was having five rows giving a total plot size of 12.5 m^2. The agricultural practices were managed according to the recommended. During the sowing process, the spacing between plants is 25 cm while between the rows was 50 cm, two seeds was placed in each hill, then thinned into one plant in a hill one-week after emergence to have a plant density of 80000 plants/ha. All plots were fertilized with 180 kg N/ha in 2 doses; 50% of the nitrogen fertilizer and 70 kg P_2O_5/ha at sowing time and the other 50% applied manually when the plants reached 25-30 cm. During harvest time, the data was collected from the harvest area of 6.0 m^2 having 48 plants/6.0 m^2 eliminating two rows of 5.0 m long from outside and two plant lines from each sides. Days to silking was counted from sowing until the day 50% of the plants produced silk whereas maturity period was counted since sowing date until the kernel moisture reached 73±1% [38]. Ten plants per each plot were randomly selected to measure plant height, number of tillers per plant, number of leaves per plant, number of ears per plant and, first ear height. At harvest, the number of plants per hectare, unhusked fresh ear yield, number of marketable ears per hectare, yield of marketable ear, number of kernel rows per ear, number of kernels per row, number of kernels per ear, fresh kernel yield and, green mass yield was determined in each plot. Marketable ears had at least 15 cm of grains ear length and 3 cm of diameter. The data obtained in this research was subjected to variance analysis in accordance with the experimental design using SAS 9.0 statistical analysis software program, the differences between the varieties were tested according to Duncan multiple comparison tests.

III. Results and Discussions

3.1 Days to silking and maturity

The silking period of the studied sweet corn varieties was statistically significant and varied between 76.17-90.67 days (Table 2). The earliest variety in terms of silking period was Signet variety followed by Argos Challenger and Tanem F_1. It was observed that the latest varieties in terms of silking period was BATEM Tatlı. Under the same conditions, it was revealed that the main reason for the different silking period was the genetic structure of the varieties and the earlier studies showed significant differences between the sweet corn varieties with respect to the silking period. According to [50], silking period in sweet corn varieties varied between 69.8-74.7 days in Eskişehir, Turkey, [40] 65.6-74.9 days under Spain conditions, [28] has determined it to be between 59.0-62.0 days in Pakistan conditions. When compared with the other research results, it is noteworthy in this study that silking period was observed to be longer. In this result, beside the earliness characteristics of the varieties, it is mainly related to the high altitude and the low average temperatures, thus to fulfil the total temperature requirement for the silking period, it needs a longer period under Erzurum conditions. The differences between the varieties in terms of the silking and the maturity (silking-harvest) periods are 14.6 and

4.7 days, respectively, indicating that the growing period is mainly related to the silking period. This trait is important under ecological conditions in which the vegetation period is limited, such as Erzurum and the variety can reach the harvest maturity confidently, and in the ecology where the vegetation period is long enough, it gives the opportunity to the cultivation of a main crop.

The maturity periods of the sweet corn varieties ranged between 105.67-120.17 days. Signet was the earliest variety in terms of the maturity period, while BATEM Tatlı was the latest. As a matter of fact, the silking period was between 76.17-90.67 days, and the period from the silking until the maturity changed between 29.50-30.00 days. In the conditions of Erzurum plain, where the altitude is very high and the average daily temperature is low, the vegetation period for corn is limited which is a very important trait for corn varieties to reach the harvest maturity confidently. All varieties included in this study have reached harvest maturity before the first frosts of autumn with maturity periods. However, according to the US conditions the varieties used were varied between 64.0-94.0 days [58], in Slovakia conditions 82.5-106.5 days [8], in Izmir, Turkey conditions 83.0-87.0 days [26], compared to these reported maturity periods in this research it was longer. In this study as mentioned under silking period trait, the difference among the varieties may be related to their genetic structure, and mainly the high altitude and low temperatures in Erzurum conditions is the reason for sweet corn requirements of the long harvest maturity period.

Table no 2. Mean values of sweet corn varieties for days to silking, days to maturity, plant height, and the number of tillers per plant[1]

No	Varieties	Days to silking (day)	Days to maturity (day)	Plant height (cm)	Number of tillers per plant
1	Argos	84.50^{c}	116.00^{c}	183.48^{e}	0.73^{d}
2	Baron F_1	85.67^{c}	117.00^{bc}	184.38^{de}	1.07^{b}
3	BATEM Tatlı	90.67^{a}	120.17^{a}	206.60^{b}	1.22^{b}
4	Challenger	84.67^{c}	117.50^{bc}	186.38^{de}	0.80^{cd}
5	Febris	88.50^{b}	119.17^{ab}	181.15^{ef}	0.13^{f}
6	Khan F_1	$88.^{83ab}$	118.50^{ab}	194.37^{cd}	0.82^{cd}
7	Kompozit Şeker	88.67^{b}	117.50^{bc}	215.97^{a}	0.98^{cde}
8	Overland	89.83^{ab}	120.00^{a}	184.67^{e}	0.82^{bc}
9	SHY1036	89.17^{ab}	118.67^{ab}	201.52^{b}	0.40^{e}
10	Signet	76.17^{d}	105.67^{e}	169.97^{g}	1.50^{a}
11	Tanem F_1	84.67^{c}	113.67^{d}	172.20^{fg}	1.03^{bc}
	Mean	86.48	116.71	189.15	0.86
	2017	86.73	116.30	193.92	0.98
	2018	86.24	117.12	184.38	0.75
	F value (Year)	1.86^{ns}	3.02^{ns}	17.55***	22.54***
	F value (Variety)	48.35***	27.68***	14.08***	21.45***
	F value (Y x V)	4.47**	2.05*	0.98^{ns}	18.13***
	C.V. (%)	1.71	1.52	4.04	21.52

[1] The means marked with the same letter are not different from each other. F values marked with * and *** are significant at the probability level of 0.05 and 0.001, where ns mean non-significant.

3.2 Plant height and number of tillers per plant

It has shown that there is a significant difference among the sweet corn varieties in terms of plant height. The plant heights of varieties were between 169.97-215.97 cm. The tallest and shortest plant heights were measured in Kompozit Şeker and Signet cultivars, respectively (Table 2). Usually early varieties are shorter while late varieties have taller plant height, which can change according to environmental conditions as well as cultivation techniques such as plant density, fertilization and sowing date. Because of the positive relations of the sweet corn plant height with the ear yield [39], fresh kernel yield [25], the green mass yield as silage production after without ears [50] taller sweet corn varieties can be advantageous. However, there is a high risk of lodging in tall corn varieties which is the causes for harvest difficulties, yield and quality losses [49]. In the previous researches done by [40]; [50]; sweet corn varieties were significantly varied in terms of plant height.

It was detected that the differences among the varieties in terms of the number of tillers per plant was significant. The number of tillers per plant of the varieties varied between 0.13 and 1.50. Signet had the highest variety in terms of tiller number, while Febris had the lowest (Table 2). In corn plant, the tillers are the root

stones of the main stem, which are connected to the main stem by the transmission bundles, have their own roots, and their development is controlled by genetic and environmental factors [47]; [43]. Almost all sweet corn varieties are producing a few or more tillers, especially in terms of nitrogen fertilizers, nutrients and optimum conditions in terms of humidity increases the number of tillers per plant while, high plant density decreases it [47]; [43]. In terms of number of tillers per plant, significant differences were found between sweet corn varieties in the research results that were previously conducted; in Korea between 1.0-2.3 [43] and in the USA conditions it was between 0.5-2.8 (Shelton and Tracy 2013). Tillering, especially in cases where there is a lack of seedlings it provides an opportunity to produce silage and green mass yield by obtaining a higher amount of dry matter per unit area. Elimination of tillers lead to the reduction of the plant height and ear yield [43]; [27] or significantly not affecting [2].

3.3 Number of leaves and ears per plant

The number of leaves per plant of the sweet corn varieties was ranged between 8.00-10.95 as average of two years (Table 3). The highest number of leaves per plant was obtained by Febris variety, while Signet was the lowest. The plant leaf area, leaf area index and number of leaves per plant, which is the element of plant canopy; is one of the critical factors affecting the light eclipse, light distribution in the plant canopy, photosynthesis and the yield [30]; [18]. While the genotypes with a high number of leaves may be suitable for silage production due to the high leaf biomass amounts in silage yield, it may not be suitable for high kernel yield due to the low photosynthetic activity of the leaves under the knuckle knot due to shadow effect during kernel filling stage [52]. It was also found in the previous research that sweet corn varieties were significantly different in terms of number of leaves per plant; which was 14.4-18.4 in Canada conditions [12], 13.1-18.1[15] in New Zealand conditions, 10.0-12.5 [29] in Iran conditions. The number of leaves in corn plant is influenced by tasselling period, temperature, day length, soil fertility and soil moisture content factors and their interactions [12]. It was stated that the number of leaves per plant was not significantly affected by plant density [12], that it increased in high nitrogen doses and did not change according to the planting geometry [33]; [18], it decreased in early and late sowing dates [12]; [58]. In this study, the lower number of leaves per plant compared to those in the literature reviews may be due to the lower temperature conditions in Erzurum where the research was conducted [13].

Table no 3. Mean values of sweet corn varieties for the number of leaves per plant, number of ears per plant, first ear height, and the number of plants per hectare[1]

No	Varieties	Number of leaves per plant	Number of ears per plant	First ear height (cm)	Number of plants per hectare
1	Argos	10.25^{abc}	1.00^{d}	58.52^{cd}	66388.83^{e}
2	Baron F_1	9.18^{ef}	1.03^{cd}	58.83^{cd}	69444.50^{de}
3	BATEM Tatlı	9.73^{b-f}	0.98^{d}	77.75^{a}	76944.44^{abc}
4	Challenger	10.13^{a-d}	1.02^{d}	51.67^{e}	74722.22^{a-d}
5	Febris	10.95^{a}	1.00^{d}	58.42^{cd}	77222.17^{abc}
6	Khan F_1	9.25^{def}	1.03^{cd}	59.17^{cd}	70833.39^{de}
7	Kompozit Şeker	9.42^{c-f}	1.05^{cd}	73.50^{a}	79166.67^{a}
8	Overland	9.95^{b-e}	1.13^{b}	68.30^{b}	71666.67^{cde}
9	SHY1036	10.62^{ab}	1.10^{bc}	62.42^{c}	70000.00^{de}
10	Signet	8.00^{g}	1.28^{a}	37.25^{f}	73055.56^{bcd}
11	Tanem F_1	8.92^{f}	1.00^{d}	54.92^{de}	77500.00^{ab}
	Mean	9.67	1.06	60.07	73358.59
	2017	8.87	1.05	66.22	72171.72
	2018	10.48	1.06	53.91	74545.45
	F value (Year)	93.74***	0.16^{ns}	122.24***	3.98*
	F value (Variety)	9.25***	12.49***	34.92***	4.24***
	F value (Y x V)	2.96*	2.15^{ns}	2.48**	0.14^{ns}
	C.V. (%)	7.19	5.65	5.89	5.82

[1] The means marked with the same letter are not different from each other. F values marked with * and *** are significant at the probability level of 0.05 and 0.001, respectively, where ns mean non-significant.

The number of ears per plant of sweet corn varieties in this research varied between 0.98-1.28. The highest number of ears per plant was obtained by Signet (1.28) which has been significantly superior to other

varieties and followed by Overland (Table 3). Corn yield; due to the number of plants per the unit area, number of ears per plant, number of grains per ear and the grain weight are the functional four yield components, and the modern varieties often have a well-developed ear. High number of ears are particularly advantageous in conditions where there is a drought risk, and since the number of ears is used as a commercial unit, the high number of ears is an important strategy to increase the yield and income in sweet corn production [59]. However, due to the significant variety x environment interactions, the selection of superior varieties in terms of the number of ears per plant is difficult and the highest number of ears that variety is obtained in the optimum environmental conditions for that variety [23]; [59]. Relevant researches showed that the sensitivity of the number of ears per plant is related to changes of the environmental conditions; significant differences were determined according to plant density and nitrogen doses [55]; [54], sowing date and soil moisture [56]; [23]. In previous research, significant differences between sweet corn varieties were pointed out in terms of the number of ears per plant; According to the varieties, the number of ears per plant was determined between 1.35-1.68 in Bursa [56], 1.56-1.96 in Eskisehir [50] and 1.22-1.60 in Diyarbakır conditions [3]. When compared these results, the number of ears per plant in our research is low. This result may be due to the high altitude effect of the research area in Erzurum [32].

3.4 First ear height and number of plants per hectare

In corn cultivation, ear harvest is usually made by machine in large production areas and by hand in narrow production areas. The height of the first ear from the soil surface is particularly important in terms of machinery harvest. When the first ear is close to the soil surface it makes the harvest difficult and it adversely affects the ear health, and when the first ear is too high in weak-stem varieties it can lead to loss of productivity as a result of lodging. Significant differences were determined between the sweet corn varieties in terms of the first ear height (Table 3). According to the first ear height, the variants have ranged between 37.25-77.75 cm, Signet has the lowest in terms of first ear height, and the highest was BATEM Tatlı variety. Sweet corn varieties in terms of the first ear height as it was determined significantly different in previous researches due to their genetic structure, as it was determined in Şanliurfa 55.9-70.1 cm [36] and in the USA conditions 30.7-63.5 cm [34]. In addition to the characteristics of the varieties, it might be influenced by high plant density and other environmental factors. Because the height of first ear is increasing in varieties with higher plant height [36], high plant density [55]; [41], high nitrogen doses [16] and the delay of sowing date [56].

The number of plants per hectare of the varieties ranged between 66388.83 and 79166.67 plants. The highest number of plants per hectare was obtained from Kompozit Şeker, while the lowest was from Argos. Since modern corn varieties usually have a well-developed ear, the number of plant ears per hectare during harvest is the most important determinant of yield and income. In order to achieve high yield, although it is usually shown at the density that provides optimum plant density, to reach the targeted adequate plant density during a harvest is one of the most important imperfections. Because, to achieve high ear yield, it is very important to maintain and protect the optimum plant density until the harvest [33]. In this study, although 80000 plants per hectare was targeted, no variety could be able to reach that plant density during a harvesting date, as a result of that, the plant density were lower than the target number plant by of 1% to 17% based on the varieties. As a result of the reduction in kernel starch content, the germination rate, emergence rate and the seedling force in sweet corn varieties are lower than traditional corn varieties, the seedling plant is known to be more irregular [7]; [53]. In this study, the germination test results in the laboratory conditions before planting showed that the germination rate of the varieties was between 75-85%. Although two seeds were planted in each hill, but there were some hills found without emerged seedlings [40], found a significant difference among the sweet corn varieties in terms of emergence rate (39.8-72.3%) and the seedling vigor. In the cool-humid environment during the spring months the high seedling rate of normal sweet varieties have caught attention. [46] found thathigh sugar content in super sweet corn varieties, and the sugar rates conversion to starch is too low, but due to the loss of their seed viability a decrease of 34% plant from the ideal plant density was observed. The results of this research are also supported by the findings in the literature reviews. The plant density during harvesting time, apart from the genetic factors, is affected by the environmental conditions (soil structure, sowing date, sowing depth, moisture, temperature, diseases, damages, mechanical effects etc.). Especially in a cool-wet spring ecologies with a short vegetation period, such as Erzurum, success of sweet corn production is limited due to the reduction of seed emergence and weak seedling development.

3.5 Ear yield and number of marketable ears per hectare

It was determined that there were significant differences between the sweet corn varieties in terms of fresh ear yield and number of marketable ears per hectare (Table 4). It was determined that the fresh ear yield of the varieties had varied between 9442.89-18790.44 kg ha^{-1}. The highest ear yield was obtained from Signet variety, the second is Challenger. The lowest ear yields were obtained from BATEM Tatlı and Kompozit Şeker varieties. Ear yield can be affected by the number of ears per plant, ear length, ear diameter, number of kernels per ear, and the kernel weight. The important differences between the sweet corn varieties in terms of these

traits are mainly a result of the genetic structures of the varieties. In sweet corn production, high ear yield is one of the most important criteria in the selection of the varieties, and it was also determined in the previous studies that there was a significant difference among the varieties in terms of ear yield. The ear yield obtained in this research is close to the one obtained from the previous sweet corn varieties adaptation studies in Izmir conditions 1241-1610 kg/da [14], Şanliurfa conditions 1059-1637 kg/da [36], and in Brazil conditions 1162-1245 kg/da [39]. The appearance of this status is referring to the effect of the highest average temperature during the research period than the long years/term average temperature in Erzurum. The fresh ear yield of sweet corn varieties varies according to environmental conditions and cultivation techniques. Researches related to the subject showed a significant impact of locations [57], sowing geometry [54], plant density [55], nitrogen dose [39]; [54], sowing date [56], and irrigation conditions [19] on the fresh ear yield of sweet corn varieties.

Table no 4. Mean values of sweet corn varieties for the ear yield, number of marketable ears, and the number of kernel rows per ear[1]

No	Varieties	Ear yield (kg/ha)	Number of marketable ears per hectare	Yield of marketable ear (kg/ha)	Number of kernel rows per ear
1	Argos	16042.39^{bc}	64166.83^{a}	15377.22^{a}	17.72^{bc}
2	Baron F_1	15489.50^{cde}	41722.39^{b}	12622.22^{c}	17.93^{b}
3	BATEM Tatlı	9442.89^{g}	17763.06^{c}	3472.72^{d}	14.12^{h}
4	Challenger	17090.06^{b}	66944.50^{a}	15341.72^{a}	17.17^{cd}
5	Febris	15942.28^{bcd}	61111.06^{a}	15203.39^{ab}	18.10^{b}
6	Khan F_1	16886.17^{bc}	61944.44^{a}	16194.50^{a}	15.77^{f}
7	Kompozit Şeker	10827.78^{f}	12611.06^{c}	3205.00^{d}	15.08^{g}
8	Overland	14242.61^{e}	48055.67^{b}	12618.28^{c}	18.07^{b}
9	SHY1036	15287.72^{de}	42777.89^{b}	11340.50^{c}	18.93^{a}
10	Signet	18790.44^{a}	62500.06^{a}	16858.28^{a}	16.10^{ef}
11	Tanem F_1	15953.39^{bcd}	60277.94^{a}	13886.06^{b}	16.57^{de}
	Mean	15090.47	49079.54	12601.81	16.87
	2017	15261.62	49191.92	12144.95	16.98
	2018	14919.33	48967.15	12604.12	16.75
	F value (Year)	0.89^{ns}	0.02^{ns}	0.14^{ns}	3.06^{ns}
	F value (Variety)	20.41***	53.52***	76.33***	46.98***
	F value (Y x V)	0.83^{ns}	0.93^{ns}	2.76**	1.92^{ns}
	C.V. (%)	7.47	11.93	8.90	3.13

[1] The means marked with the same letter are not different from each other. F values marked with ** and *** are significant at the probability level of 0.01 and 0.001, respectively, where ns mean non-significant.

Profitability in sweet corn production is closely related to both quantity and quality of the ears, especially, in the production of sweet corn for fresh consumption, that is why the high number of marketable ears are one of the main objectives. In this study, the number of marketable ears per hectare of the sweet corn varieties ranged between 12611.06-66944.50. The highest number of marketable ears was obtained from Challenger variety, followed by Argos. The lowest number of marketable ears was obtained from Kompozit Şeker and BATEM Tatlı varieties (Table 4). The number of marketable ears has a joint factor with the number of plants during harvest and the number of marketable ears per plant, in terms of the number marketable ears, and due to the effect of the genetic factors on these traits sweet corn varieties can show a significant difference. In previous researches, it was determined that the number of marketable ears per hectare of sweet corn varieties was between 25486 and 34805 in Puerto Rico conditions [31] and 54714-55800 in Poland conditions [44]. On the other hand, researches have revealed the sensitivity of marketable ears number to environmental conditions and differences in cultivation techniques; plant density [43], nitrogen dose [45] and irrigation [19]; [35] determined a significant difference according to each study.

3.6 Yield of marketable ear and number of kernel rows per ear

There are significant differences among the varieties in terms of the yield of marketable ear and number of kernel rows per ear (Table 4). The yield of marketable ear of the sweet corn varieties ranged between 3205.00-16858.28 kg/ha. The highest marketable ear yield was obtained from Signet variety, followed by Khan F_1 and Argos varieties, respectively. The lowest marketable ear yields were obtained from Kompozit Şeker and BATEM Tatlı varieties. The yield of marketable ear can vary according to the genotype, environment and the

cultivation techniques. In this research, the ratio of the marketable ear yield to the total ear yield varied between 30.0% and 95.9%, according to the varieties, the highest rate was obtained from Tanem F_1 and Argos, while the lowest was determined in Kompozit Şeker and BATEM Tatlı varieties. As the yield of marketable ear is essential, especially in the production for fresh consumption, it was understood that the ratio of the ear yield as well as the rate of marketable ears is a determinant factor in the selection of varieties. The marketable ear yield of sweet corn varieties obtained was 9950-10750 kg/ha in Isparta conditions [2], 7010-7430 kg/ha in South Korea [43], 8977-9980 kg/ha in Brazil [39], 13030-13560 kg/ha in Poland [44], and 15815-25452 kg/ha in USA conditions [34]. It can be mentioned that the yield of marketable ear obtained in this study is generally close to the results reported in the literature reviews. The effect of the ecological conditions and cultivation techniques on the yield of marketable ear showed a significant differences based on cultivation seasons [44]; [39], plant density [43]; [2], irrigation conditions [35] and nitrogen doses [17].

The number of kernel rows per ear of the varieties ranged between 14.12 and 18.93, and the average of the varieties was determined as 16.87. The highest number of kernel rows per ear of the varieties was SHY1036, while the lowest was from BATEM Tatlı varieties (Table 4). In fact, the number of kernel rows per ear, determined by genetic factors [23] is one of the factors affecting the kernel yield per ear and the number of kernels per ear. It was also found in previous studies that sweet corn varieties were significantly different in terms of the number of kernel rows per ear; in Spain conditions 14.9-16.4 [40], in Izmir conditions 15.0-19.2 [25], in Eskisehir conditions 15.8-20.5 [50]. The number of kernel rows per ear may also vary according to environmental conditions and cultivation techniques.

3.7 Number of kernels per row and per ear

The differences among the varieties were significant in terms of the number of kernels per row and per ear (Table 5). The number of kernels per row of the varieties ranged between 30.77 and 40.33. The highest number of kernels per row was determined from Khan F_1, whereas the lowest was obtained by Kompozit Şeker varieties. The number of kernels per row was positively interacted with the ear length; therefore, it affects the yield. In the previous researches, significant differences among the varieties were found in terms of number of kernels per row [21]; [25].

Table no 5. Mean values of sweet corn varieties for the number of kernels per row, number of kernels per ear, fresh kernel yield, and the green mass yield[1]

No	Varieties	Number of kernels per row	Number of kernels per ear	Fresh kernel yield (kg/ha)	Green mass yield (kg/ha)
1	Argos	36.12^{cd}	618.70^{c}	9604.00^{c}	39386.33^{c}
2	Baron F_1	36.12^{cd}	618.77^{c}	6854.50^{ef}	43836.61^{b}
3	BATEM Tatlı	36.78^{bcd}	519.33^{e}	2411.83^{g}	48084.94^{a}
4	Challenger	35.60^{d}	611.55^{cd}	11833.33^{a}	41766.89^{bc}
5	Febris	37.35^{bc}	676.24^{b}	7664.00^{de}	48352.22^{a}
6	Khan F_1	40.33^{a}	635.46^{c}	8948.33^{c}	42148.89^{bc}
7	Kompozit Şeker	30.77^{e}	461.14^{f}	1681.50^{g}	48908.94^{a}
8	Overland	39.80^{a}	718.49^{a}	7828.50^{d}	42682.78^{bc}
9	SHY1036	38.07^{b}	719.23^{a}	6226.50^{f}	49406.33^{a}
10	Signet	36.05^{cd}	579.76^{d}	11855.00^{a}	35458.33^{d}
11	Tanem F_1	36.37^{cd}	602.74^{cd}	10451.50^{b}	39341.61^{c}
	Mean	36.67	614.67	7759.91	43579.44
	2017	35.38	601.45	8013.55	43032.83
	2018	37.96	627.90	7506.27	44126.06
	F value (Year)	74.66***	13.85***	9.21**	2.21^{ns}
	F value (Variety)	25.49***	43.20***	148.58***	14.33***
	F value (Y x V)	7.50***	2.52*	3.79**	1.76^{ns}
	C.V. (%)	3.31	8.79	11.34	6.86

[1] The means marked with the same letter are not different from each other. F values marked with *, ** and *** are significant at the probability level of 0.05, 0.01 and 0.001, respectively, where ns mean non-significant.

The numbers of kernels per ear of the varieties have been determined to vary between 461.14 and 719.23. The highest number of kernels per ear was obtained by SHY1036 and Overland varieties; while the lowest number has been determined from Kompozit Şeker (Table 5). In the previously conducted researches,

significant differences were determined between the number of kernels per ear of the sweet corn varieties. According to the varieties, the number of kernels per ear was between 541-638 in İzmir [22], 531.3-749.9 in Şanlıurfa [36], and 688-917 in Eskişehir conditions [10]. The number of kernels per ear can also vary depending on the environmental conditions and cultivation techniques as well as related to respond of the ear length and number of kernel rows per ear. Relevant studies showed that plant density and nitrogen dose [55]; [36], sowing date [37] and irrigation conditions [19] are significantly affected the number of kernels per ear.

3.8 Fresh kernel yield

The variance analysis results of the fresh kernel yields of the 11 sweet corn varieties used in this study and the fresh kernel yields are presented in Table 5. It was determined that the differences amoung the varieties was significant in terms of fresh kernel yield.

Fresh kernel yields of the sweet corn varieties ranged between 2411.83-11855.00 kg/ha. Signet, Challenger, Tanem F_1, and Argos varieties had the highest fresh kernel yields whereas the lowest was obtained from BATEM Tatlı (2411.83 kg/ha) variety, and this variety have significantly lower grain yields than the other varieties (Table 5). While the main target in fresh sweet corn production is to provide higher ear yield, the main target in the production for canned and frozen products is to obtain a higher kernel yield [45]. The grain yield, which has a complex structure which is the result of the dynamic equilibrium among the yield elements, varies according to the genetic structure as well as the environmental conditions and cultivation techniques. According to the varieties, fresh kernel yield in Diyarbakır conditions was determined between 556.1-743.4 kg/da [6], İzmir conditions 961.4-1358.9 kg/da [25], in Eskişehir conditions 1437,0-1756,0 kg/da [9] in Karaman conditions 700.0-996.7 kg/da [20], in Tekirdağ conditions 1018.8-1101.3 kg/da [42], in Siirt conditions 416.5-803.9 kg/da and Sakarya conditions was between 462.8-889.6 kg/da [57]. Compared to the results in the literature reviews, this research draws attention due to the wide range of variation in fresh kernel yield. This may be the result of varietie's ability to adapt to the ecological conditions of Erzurum, as well as the yield potential of the varieties used in this research. However, for the two varieties with the lowest yields are excluded, the yield of the fresh kernel obtained is generally close to the yields of the other locations of Turkey. Fresh kernel yields may also vary significantly according to the locations [57], sowing date [58]; [23], harvest date [53], plant density [42], nitrogen and phosphorus doses [4]; [45] and irrigation applications [23].

3.9 Green mass yield

Significant differences were observed among the varieties in terms of green mass yield (Table 5). The green mass yield varied between 35458.33-49406.33 kg/ha according to the varieties. The highest green mass yield was obtained by SHY1036, followed by Kompozit Şeker and Febris variety. The lowest green mass yield values were obtained from Signet and Tanem F_1 varieties. Since the remaining green parts of the sweet corn are a valuable green mass yield and silage material [5], sweet corn varieties that can be used both for food and forage may have higher added value for farmers. The green mass yield of the sweet corn varieties was determined between 16323-19305 kg/ha in Diyarbakır [6], 21553-29093 kg/ha in Karaman[20], and 33639-35886 kg/ha in Kahramanmaraş conditions [24]. In addition to environmental and genotypic factors, green mass yield in sweet corn can vary according to the number of plants per hectare, sowing date, fertilization and irrigation conditions. [43] reported that the green mass yield was 31160-38300 kg/ha according to the varieties and the highest green mass yield (40680 kg/ha) was obtained by 111110 plants per hectare. [60], pointed that according to the varieties, the yield of green mass was varied between 21800-34000 kg/ha, and the reduction of the green mass yield with the delay in planting and plant density of less than 90000 plants per hectare has attracted attention [41] reported that the green mass yield increased by the increase of plant density and nitrogen doses. The highest green mass yield (25590 kg/ha) was obtained by 140000 plants per hectare and by 250 kg N/ha.

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