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Evaluation of some agro-morphological parameters in commercial sweet corn (*Zea mays* L. saccharata Sturt) hybrids under greenhouse conditions

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ABSTRACT

Sweet corn (*Zea mays* (L.) var. saccharata) is a cereal grown in almost every region of the world and is widely cultivated for human consumption. Moreover, it serves as both a raw and processed ingredient in the global food industry. Its breeding programs optimize yields and many agro-morphological traits through the development of hybrids, which contributes to its worldwide popularity. This study aimed to assess some agro-morphological parameters of 13 commercial sweet corn hybrids during two years under greenhouse conditions. These parameters included plant height (PH), stem diameter (SD), first ear height (FEH), leaf width (LW), number of nodes (NN), number of ears (NE), number of leaves (NL) and tassel initiation day (TI). The two-year average results showed that PH and FEH had a mean of 167.96 and 61.48 cm, ranging from 133.12 to 205.5 and 77 to 31.83 cm, respectively. For SD, the average was 21.28 mm with the highest value recorded by Khan (28.75 mm), followed by Driver (24.62 mm). The earliest TI was observed by Khan (52), succeeded by Challenger, Fragman and SF 2070 with same value of 55 days. In addition, there was a significant variation (at least $P \leq 0.05$) for all traits across the two years. The highest values were observed in SF 2070 for LW, Messenger for NN, 10514 for NE and Febris for NL. Based on the findings of this study, different sweet corn hybrids may be recommended for both breeding programs and cultivation, depending on their specific agro-morphological traits.

1. Introduction

Corn (*Zea mays* L.) is one of the most widely grown cereals in the world (Sanodiya et al. 2023). It belongs to the Poaceae family and was domesticated in Central America (Phiarais and Arendt 2008; Kennett et al. 2020). It is cultivated in almost every region in the world and remains the third most important crop after wheat and rice (Phiarais and Arendt 2008; Kaushal et al. 2023). Its production in 2023 is estimated at 1.24 billion tons on an area covering 208.23 million ha, with the major producers including the USA, China, Brazil, Argentina and India (FAOSTAT 2025). Corn is used for food and feed and, is an ideal source for biofuel production (Courtois et al. 1991; Wallington et al. 2012; Venadan et al. 2024). It is known under different specialized varieties such as sweet corn, which has high sweetness concentration and nutritional values (Hallauer 2001; Dang et al. 2023).

Sweet corn (*Zea mays* (L.) var. saccharata), generally known as a fruit and vegetable product, derives from the spontaneous mutation of the relative gene which regulates the transformation of sugar to starch in the endosperm of kernels (Feng et al. 2020; Yu et al. 2023). It is characterized by light yellow seeds with a high moisture (around 70%) and sugar content 25-30% higher than normal corn varieties (Rah Khosravani et al. 2017; Wang et al. 2023a). It contains precious components such as vitamins, minerals, dietary fiber and phytonutrients while possessing antioxidant, anti-diabetic, anti-inflammatory, and anti-cancer properties which have multiple benefits for human health (Liu et al. 2014; Joshi et al. 2017; Xiao et al. 2022). These properties explain its high preference in the USA, Europe, Asia, and developing countries in the world (Rathinavel et al. 2024). Despite increasing demand for sweet corn, its growth is confronted by rigorous market requirements to satisfy high quality and appearance norms (Alan et al. 2024). It requires important traits such as plant height, ear height and particularly commercial yield for the producers, and it is mostly used in fresh, canned or frozen form (Mahato et al. 2018; Alan et al. 2024).

Nowadays, sweet corn is largely improved through selection and hybridization (Szymanek et al. 2015). These hybrid varieties have higher yields and offer better uniformity and quality (Kumari et al. 2006). Many agro-morphological traits contribute to the overall hybrid productivity of the crop, including plant height, stem diameter, first ear insertion height, etc. Plant height is regarded as a crucial parameter for assessing crop growth conditions and predicting yield potential (Zhao et al. 2024). This trait significantly contributes to enhancing the lodging resistance of corn and grain yields (Liu et al. 2021). In the diverse range of agronomic parameters in corn, stem diameter also plays a crucial role in obtaining high yield. It functions not only as a predictor for yield estimation and evaluation of lodging resistance but also as an important metric for forecasting seasonal biomass accumulation in corn (Kelly et al. 2015: Liu et al. 2022). Enhanced plant development increases the probability of leaf production (Subaedah et al. 2018). The presence of more leaves

and greater leaf areas facilitates the capture of increased solar energy. This could accelerate the photosynthesis process at an increased rate, ultimately resulting in plants that exhibit enhanced growth and productivity (Mansfield and Mumm 2014).

The aim of the present study was to evaluate some agro-morphological parameters, including plant height, stem diameter, first ear height, number of nodes, ears and, leaves of commercial sweet corn hybrids, in two years. Our results will assist the understanding of agro-morphological parameters underlying sweet corn yield-related traits.

2. Materials and Methods

This research was conducted in the greenhouse of Akdeniz University (36°53' N, 38°30' E and altitude of 15 m) from February to June 2023 and 2024. Thirteen sweet corn hybrids were used in the present study which have been released by international companies in Türkiye. The experiments were conducted in a randomized complete block design with three replicates. Prior to the seeding process, the plant residues were removed, and a drip irrigation system was installed in the greenhouse. The recommended standard practices were adhered to throughout the procedure. Seeds were planted in rows measuring 5 m in length, with a distance of 0.7 m maintained between each row and a spacing of 0.2 m between individuals. The weather data recorded for the growth period during 2023 and 2024 revealed that average weekly minimum and maximum temperatures ranged from 12.1 to 41°C and 13.8 to 44.5°C, respectively.

From each plot, three plants were randomly selected at harvest stage for evaluation of agro-morphological parameters. Plant height (PH) was measured as the distance from the soil of the plant to top of the tassel (cm). The measurement of the stem diameter (SD) at the third node from the base of the main stem was conducted utilizing a digital caliper in conjunction with an LCD Stainless Electronic Ruler Micrometer (Clockwise Tools DCLR-0605 Electronic Digital Caliper) (mm). First ear height (FEH) was measured from the ground to first ear (cm). The leaf width (LW) was determined at harvest by selecting the largest part of each leaf selected and recorded in cm. The number of nodes (NN), ears (NE) and leaves (NL) were counted. Tassel initiation day (TI) was determined as the day from planting to tassel emergence.

Analyses of variance (ANOVA, PROC GLM) was performed with SAS 9.0 software.

3. Results and Discussion

Sweet corn is an agricultural crop cultivated for human consumption and an important component of the world's food sector (Swapna et al. 2020). Sweet corn breeding programs, like field corn, prioritize enhancing yield through the development of commercial hybrids. Many agro-morphological traits contribute to the overall hybrid productivity and yield of the crop. In this study, PH, FEH, SD, LW, NN, NE, NL and TI, which are among the important traits in commercial hybrid varieties, were evaluated over two years using 13 hybrid cultivars in a greenhouse. The results indicated that the variations among cultivars were significant (at least $P \leq 0.05$) across all traits. However, the effect of the years was statistically significant only for FEH and NE (Table 1).

PH is a crucial component of sweet corn growth, which influences its yield and provides economic benefits (Thapa et al. 2024). The results indicated that the two-year average PH ranged from 133.12 to 200.50 cm with a mean of 167.96 (Table 2). These results were significantly different from those of Ekiz (2021) in similar conditions, which indicated that PH varied from 152.20 to 337.80 cm. Atakul (2011) and Karacadal (2017) reported that

Table 1. Analysis of variance for some agro-morphological parameters sweet corn hybrids across the two years

Source	PH	SD	FEH	LW	NN	NL	NE
Year (Y)	NS	NS	*	NS	NS	NS	**
Cultivar (C)	**	**	**	**	**	**	**
Y x C	NS	NS	NS	NS	NS	**	NS

*, **: indicates significance at $P \leq 0.05$ and $P \leq 0.01$, respectively; NS indicates not significant; PH: plant height; FEH: first ear height; SD: stem diameter; LW: leaf width; NN: number of nodes; NE: number of ears; NL: number of leaves.

Table 2. Mean values of sweet corn hybrids for PH, FEH, SD, LW, NN, NL and NE across the two years

Cultivars	PH (cm)	FEH (cm)	SD (mm)	LW (cm)	NN	NL	NE
Messenger	169.87	74.50	24.50	7.62	11.87	9.00	1.50
Challenger	154.00	53.50	17.00	6.12	8.87	7.25	1.25
Khan	167.00	56.75	28.75	7.75	9.87	7.25	1.50
10514	166.62	61.25	20.62	6.93	10.87	9.75	2.37
SHY6RH1036	177.25	59.12	21.80	8.00	10.25	8.37	2.00
Sentinel	197.87	77.00	16.62	6.25	9.87	9.00	1.25
Vega	170.06	53.52	17.87	6.00	8.75	9.50	1.25
Caramelo	133.12	56.12	23.50	6.81	9.12	7.00	1.37
Fragman	172.08	56.15	18.75	5.93	8.87	9.50	1.75
SF 2070	142.20	31.83	22.62	8.15	8.25	9.37	1.75
SF 1280	158.50	72.50	22.37	7.00	9.75	7.75	1.12
Driver	200.50	71.75	24.62	5.87	10.87	9.62	1.75
Febris	174.46	75.36	17.62	6.86	10.00	11.62	1.37
Means	167.96	61.48	21.28	6.86	9.61	8.84	1.55
LSD	15.53**	10.53**	3.51**	0.96**	0.82**	0.87**	0.61**

*, **: indicates significance at $P \leq 0.05$ and $P \leq 0.01$, respectively; PH: plant height; FEH: first ear height; SD: stem diameter; LW: leaf width; NN: number of nodes; NL: number of leaves; NE: number of ears.

it varied between 170.00-204.00 cm and 205.00-248.00 cm, respectively. This variation was probably due to humidity, precipitation, and temperature affecting PH (Turhal 2010). It was also influenced by its production environment (Yozgatlı et al. 2019). The results of the average for the two years showed that the highest PH value was recorded by Driver (200.50 cm), followed by Sentinel (197.87 cm) and SHY6RH1036 (177.25 cm). Caramelo had the shortest PH with 133.12 cm. Our result for Caramelo was similar to Tezel et al. (2021) who reported that it (128 cm) had the shortest PH value over two years. SD represents stem thickness and is considered to be an essential agronomic yield component of sweet corn (Iqbal et al. 2015). For the average of two years SD was 21.28 mm and Khan recorded the highest value (28.75 mm), followed by Driver (24.62 mm). Our results were different compared to those obtained by Ağaçkesen and Öktem (2022) which showed SD ranging between 21.90 and 23.90 mm. This difference can be attributed to different genotypic factors, variability between years, and characteristics of the plants (Hallauer et al. 2010; Ağaçkesen and Öktem 2022).

FEH is one of the phenotypic characteristics that provide the information on the vertical structure of the sweet corn and affect its yield (Wang et al. 2020; Wang et al. 2023b). In this study, Sentinel recorded the highest FEH with 77.00 cm, while SF 2070 exhibited the lowest with 31.83 cm, resulting in an average FEH of 61.48 cm over the two-years (Table 2). Similar results were confirmed by Tezel et al. (2021) and Kılınç et al. (2021), who reported that FEH ranged from 35.20 to 79.80 cm and from 45.83 to 70.68 cm, respectively. This trait is influenced by genetic and environmental factors (Sönmez 2000; Yozgatlı et al. 2019). Recent studies reported that there are significant variations between genotypes for the FEH, which varies depending on PH (Anıl and Sezer 2003; Öktem and Öktem 2006; Tezel et al. 2021). Sentinel showed this finding by exhibiting one of the tallest plant heights recorded in this research.

LW, which is considered an important characteristic in plant light competitiveness (Sinoquet and Caldwell 1995; Gao et al. 2021), is an important parameter in plant architecture that considerably impacts photosynthesis and yield (Gao et al. 2021). An average of two-year results indicated that LW ranged between 5.87 and 8.15 cm, with an average of 6.86 cm (Table 2). Our result was lower than the results obtained by Utari et al. (2023), who found a mean value of 9.40 cm. Research by Lu et al. (2024) in two years showed that it had an average value of 8.10 and 8.30 cm in 2015 and 2016, respectively. In our study, the lowest LW was observed in Driver F1 (5.87 cm), followed by Fragman (5.93 cm), while the highest LW was identified in SF 2070 (8.15 cm). This difference shows the variation in LW of sweet corn among cultivars (Utari et al. 2023).

NN plays an important role in maintaining the plant upright and in nitrogen fixation (Zheng et al. 2023). Significant differences were detected at $P \leq 0.01$ level for NN among cultivars, while years and, cultivar x year interaction was not statistically significant across the two years. In this study, NN was ranged between 8.25 and 11.87 with an average of 9.61 (Table 2). A study conducted by Heuer et al. (2001) under greenhouse conditions showed that it could be expected to rise up to 12.00. This explains the variation in NN among sweet corn cultivars (Heuer et al. 2001). It is crucial in regulating lodging and its decrease affects the length of sweet corn (Dong et al. 2023; Heuer et al. 2001). It also improves dry matter accumulation and allocation in the stem, which boosts the yield and yield stability of plants (Liang et al. 2025).

NE is accepted as one of the most important factors that influence sweet corn yields (Ekiz 2021). Statistical analysis showed a significant difference in NE for cultivars ($P \leq 0.01$) and the results showed that across the two years, it had an average of 1.55 and varied from 1.12 to 2.37. 10514 (2.37) recorded the highest value followed by SHY6RH1036 with the value of 2.00 (Table 2). Our results were different from İdikut et al. (2005) and Turgut and Balci (2002), which showed that NE ranged from 1.00 to 1.30 and 1.35 to 1.68, respectively. It generally varied according to the cultivar, sowing dates and environment (Bozokalfa et al. 2004; Eşiyok and Bozokalfa 2005; Kılınç et al. 2021).

NL remains an important factor affecting vegetation cover, photosynthesis and yield of sweet corn (Stansluos et al. 2020). It varied from 7.00 to 11.62, with an average of 8.84 across the two years (Table 2). Our result was similar to those found by Sönmez et al. (2013), which showed that it ranged from 7.90 to 11.10 and lower than that obtained by Alan et al. (2011), which ranged between 9.16 to 12.60. NL differs based on the cultivar, various characteristics, and the production environment (Ağaçkesen and Öktem 2022; Susanti et al. 2023). This affects the yield and the quantity of light received by sweet corn (Stansluos et al. 2020; Susanti et al. 2023).

The TI of sweet corn varies generally according to the genotypes (İdikut et al. 2015). The results indicated that the cultivar Messenger (69 days) had the highest number of days, followed by SF 1280 and Febris, which both had a TI value of 65 days (Figure 1). The lowest IT was observed by Khan (52), followed by Challenger, Fragman and SF 2070 with a value of 55 days. Our results were higher than those obtained by İdikut et al. (2016) and Karacadal (2017), which showed that it ranged between 60-64 and 48-52 days, respectively. However, our results were lower than the results found by Atakul (2011) with a value of 51-77 days and by Alan et al. (2011) with a value of 76-81 days. These variations can be explained by the differences between genetic structures and environmental conditions (Özata 2019; Tezel et al. 2021). It is possible to significantly reduce the TI under greenhouse conditions and obtain an early crop of sweet corn which is suitable for commercialization (Kul 2012; Ekiz 2021).

4. Conclusion

There is great interest in producing sweet corn under greenhouse conditions as the income per unit area is getting close to the income of other vegetables such as lettuce, cucumber, tomato and pepper. The fact that the labor in the greenhouse is significantly less in sweet corn compared to these vegetables reduces the input costs. Therefore, studies on yield characteristics in greenhouse conditions contribute valuable information. This study was to evaluate some agro-morphological parameters such as PH, FEH, SD, LW, NN, NE, NL and TI of 13 commercial sweet corn hybrids under greenhouse conditions. All the traits were significantly varied at least $P \leq 0.05$ across the two years. Driver and 10514 could be recommended for PH and NE, respectively. Khan cultivar was identified as the earliest TI as well as the highest SD. However, more research and additional agro-morphological traits are necessary to evaluate the performance of these commercial sweet corn hybrids under different environments.

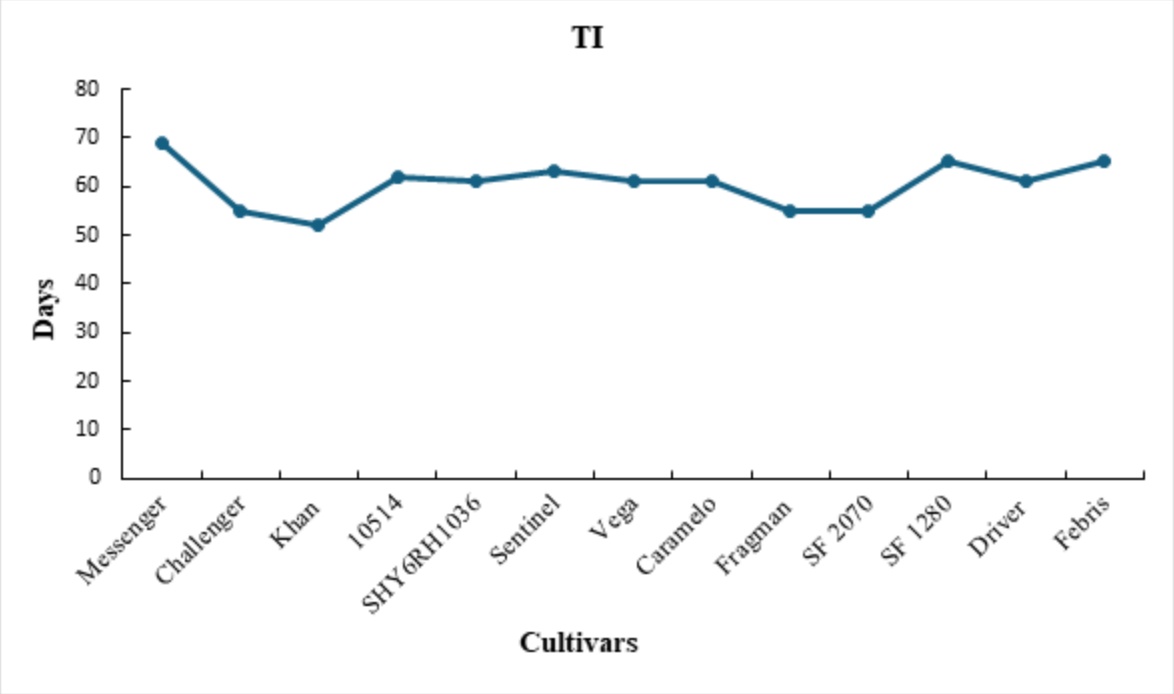

Figure 1. The average tassel initiation (TI) day of different sweet corn hybrids across the two years.

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