Uluslararası Gıda, Tarım ve Hayvan Bilimleri Dergisi (IJFAA) 2025, 5(1), 1-6
International Journal of Food, Agriculture and Animal Sciences (IJFAA)

OPEN ACCESS

BİNGÖL ÜNİVERSİTESİ

Uluslararası Gıda, Tarım ve Hayvan Bilimleri Dergisi
International Journal of Food, Agriculture and Animal Sciences (IJFAA)
e-ISSN : 2791-8807
https://dergipark.org.tr/tr/pub/ijfaa

Some Agronomic Characteristics of Sugar Sorghum (*Sorghum bicolor var. saccharatum* (L.) Mohlenbr.) Seeds

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Article info
Received: 27.11.2024
Accepted: 09.01.2025

Article type: Research

Keywords:
Sugar sorghum, *sorghum bicolor var. saccharatum* (l.) Mohlenbr., seed characteristics

Abstract

Sugar sorghum is a crop species characterized by its high sugar content, rapid growth capacity and biomass production potential. Similar to sugarcane, its ability to accumulate high sugar content makes it a valuable agricultural crop not only for food production but also for energy and other special purposes. In this study, seeds of ten different sugar sorghum (Sorghum bicolor var. saccharatum (L.) Mohlenbr.) cultivars (Cowley, Erdurmuş, Gülşeker, MDI-E, Smith, Sorge, Tracy, Ulusoy, USDA Taiwan, Uzun) were examined and their morphological (shape-dimension, surface area, mean arithmetic and geometric diameter, sphericity) and physiological (germination rate and germination time) characteristics were determined. According to the data obtained, it was determined that the varieties had a short and oval seed structure, an average length of 3.876 mm, a width of 2.976 mm, a surface area of 8.848 mm2, an arithmetic diameter of 3.426 mm, a geometric diameter of 15.549 mm and a sphericity value of 4.545 and the seeds had an average germination ability of 98-99%. Determining the physical and morphological characteristics of the seeds before the production periods plays a critical role in determining the right production method in accordance with the needs of the seed, choosing the right equipment and machinery to be used, and determining the norms. This approach will contribute to the prevention of seed losses and help producers to achieve a more efficient and sustainable production process by reducing input costs.

Citation: Özdemir, S., Dumanoğlu, Z. (2025). Some agronomic characteristics of sugar sorghum (*Sorghum bicolor var. saccharatum* (L.) Mohlenbr.) seeds. *International Journal of Food, Agriculture and Animal Sciences*, 5(1), 1-6.

Şeker Sorgum (*Sorghum bicolor var. saccharatum* (L.) Mohlenbr.) Tohumlarının Bazı Agronomik Özellikleri

Makale bilgileri
Geliş Tarihi: 27.11.2024
Kabul Tarihi: 09.01.2025

Makale türü: Araştırma

Anahtar kelimeler
Şeker sorgum, *sorghum bicolor var. saccharatum* (L.) Mohlenbr., tohum özellikleri

Öz

Şeker sorgum, yüksek şeker içeriği, hızlı büyüme kapasitesi ve biyokütle üretim potansiyeli ile dikkat çeken bir bitki türüdür. Şeker kamışına benzer bir şekilde, içerisinde yüksek oranda şeker birikimi yapabilme özelliği, onu sadece gıda üretimi değil, aynı zamanda enerji ve diğer özel amaçlar için de değerli bir tarım ürünü haline getirmektedir. Bu çalışmada, on farklı şeker sorgum (Sorghum bicolor var. saccharatum (L.) Mohlenbr.) çeşidine (Cowley, Erdurmuş, Gülşeker, MDI-E, Smith, Sorge, Tracy, Ulusoy, USDA Taiwan, Uzun) ait tohumlar incelenmiş; bu tohumların morfolojik (şekil-boyut, yüzey alan, ortalama aritmetik ve geometrik çap, küresellik) ve fizyolojik (çimlenme oranı ve çimlenme zamanı) özellikleri belirlenmiştir. Elde edilen verilere göre çeşitlerin kısa ve oval bir tohum yapısına sahip olduğu, ortalama 3.876 mm uzunluk, 2.976 mm genişlik, 8.848 mm2 yüzey alan, 3,426 mm aritmetik çap, 15,549 mm geometrik çap ve 4,545 küresellik değerine sahip olduğu ve tohumların ortalama olarak %98-99 oranında çimlenme kabiliyetine sahip olduğu tespit edilmiştir. Tohumların üretim dönemlerinden önce fiziksel ve morfolojik özelliklerinin belirlenmesi tohumun ihtiyaçlarına uygun olarak doğru üretim yönteminin belirlenmesi, kullanılacak ekipman ve makinelerin doğru seçilmesi, aynı zamanda normların belirlenmesinde kritik bir rol oynamaktadır. Bu yaklaşım, tohum kayıplarının önlenmesine katkı sağlarken, üreticilerin girdi maliyetlerini düşürerek daha verimli ve sürdürülebilir bir üretim süreci elde etmelerine yardımcı olacaktır.

Atıf: Özdemir, S., Dumanoğlu, Z. (2025). Şeker sorgum (*Sorghum bicolor var. saccharatum* (L.) Mohlenbr.) tohumlarının bazı agronomik özellikleri, *Uluslararası Gıda, Tarım ve Hayvan Bilimleri Dergisi*, 5(1), 1-6.

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Introduction

Sugar sorghum is a C4 plant belonging to the genus *Sorghum bicolor var. saccharatum* (L.) Mohlenbr. of the family Gramineae, characterized by high photosynthetic efficiency and drought resistance (Gnansounou et al., 2005; Woods, 2000; Geren et al., 2019). Due to its various economic uses, human food, grain, biomass ethanol and biofuel production, it has a rapidly increasing area of use worldwide and is the fifth most important plant in the world (Yücel et al., 2018; Ndlovu et al., 2021). Its seeds are gluten-free and rich in antioxidants, making it an important food source for celiac patients. In addition, sugar sorghum, which is grown worldwide, is largely used as green fodder or silage in animal nutrition. It is also grown for the sweet sap in its stalk. Sweet sorghum can also be used for special purposes, especially as it has a rich sugar content similar to sugar cane. The fast growth rate, high sugar accumulation and biomass production potential, together with the wide adaptability of sweet sorghum, make this crop more important than its counterparts (Reddy and Reddy, 2003).

With growing concerns about environmental pollution, energy security and future oil supplies, the global community is seeking alternative non-petroleum-based fuels and more advanced energy technologies to improve energy use efficiency. Rising energy costs and limited oil and gas reserves have created a global need to develop energy production from biomass sources and biofuels in particular (Semelsberger et al., 2006). Ethanol is emerging as a promising renewable energy source for future transportation fuels and has significant potential to increase energy security and reduce environmental impacts (Prasad et al., 2007). Sweet sorghum is considered an important energy crop, especially for ethanol production, as it is a high sugar yielding crop (Tian et al., 2005).

Each seed has its own characteristics. Even if they are the same variety, many factors such as production, irrigation, fertilization, fertilization, pesticide use, storage characteristics directly affect the climatic and environmental characteristics as well as the basic characteristics of the seed (Dumanoğlu, 2022). Therefore, it is important to determine the characteristics of the seeds before the production periods or to use the values determined in previous researches. Determining the appropriate production method according to the needs of the seed, determining the norm by making the tool-machine preferences to be used, preventing seed loss and reducing the input costs of the producers have a positive effect (Dumanoğlu, 2020; Dumanoğlu et al., 2022). In addition to these, these data are also evaluated in product processing stages such as cleaning and packaging of seeds to reduce losses and to reach quality and standard products (Dumanoğlu and Geren, 2020). In addition, knowing the basic characteristics of seeds (length, width, thickness, surface area, etc.) is useful for breeding studies (Dumanoğlu and Öztürk, 2024). In this study, some agronomic characteristics of seeds of ten different varieties of sugar sorghum, which has an important place in Turkey and in the world, were determined.

Material and Method

This research was conducted in the laboratories of Bingöl University, Faculty of Agriculture, Department of Field Crops and Biosystems Engineering in 2023. Seeds of ten different sugar sorghum varieties (Cowley, Erdurmuş, Gülşeker, MDI-E, Smith, Sorge, Tracy, Ulusoy, USDA Taiwan, Uzun) were used as plant material. The basic characteristics of seeds of sugar sorghum cultivars were determined including length (mm), width (mm), surface area (mm^2), mean arithmetic diameter (mm), mean geometric diameter (mm), sphericity and thousand-grain weight (g). The length, width and surface area of 100 randomly selected seeds were measured using a stereo microscope (Nikon SMZ 745T) with its own software. The mean arithmetic diameter ((L+W)/2), mean geometric diameter (mm) ($(LXD)^{21/3}$), sphericity (Do/L) values were calculated (Mohsenin, 1970; Alayunt, 2000; Kara, 2012) (L: Length of the seed (mm) W: Width of the seed (mm), D: Mean arithmetic diameter (mm); D0: Mean geometric

diameter (mm)). The data obtained were classified according to the geometric and shape characteristics of sugar sorghum seeds according to Yağcıoğlu (2015) (Table 1).

The seeds were randomly selected from ten different sugar sorghum seeds and germinated in four replicates in glass petri dishes under controlled conditions (24°C temperature, 60% humidity, dark environment) in a BİNDER brand incubator according to ISTA (2007).

Table 1. Classification of seeds according to geometric and shape characteristics (Yağcıoğlu, 2015)

Seeds according to their geometric characteristics	Grain width/grain length (b/a) (mm)
Long	<0.6
Middle	0.6 - 0.7
Short	> 0.7
Seeds according to their shape characteristics	Length (a), Width (b), Thickness (c) (mm)
Round	$a \approx b \approx c$
Oval	$a/3 < b \approx c$
Long	$c < b < a/3$

The data obtained were transferred to SPSS v.17 statistical package program and grouped by applying TUKEY test at $p<0.05$ significance level.

Results and Discussion

Geometric and shape characteristics of seeds of the varieties

In this study, morphological characteristics such as length, width, surface area, mean arithmetic diameter, mean geometric diameter and sphericity and physiological characteristics such as germination percentage and germination time of seeds of ten different sugar sorghum varieties were investigated. Some agronomic values of the seeds of sugar sorghum varieties are given in Table 2. According to the characteristics stated by Yağcıoğlu (2015), the seeds were found to have a short and oval seed structure. The data were transferred to SPSS v17.statistics program and TUKEY grouping was performed at $p<0.05$ significance level (Table 2).

Table 2. Some agronomic characteristics of sugar sorghum seeds

Seeds	Length (mm)	Width (mm)	Surface area $(mm)^2$	Average arithmetic diameter (mm)	Average geometric diameter (mm)	Sphericity
Cowley	3.867b	3.186a	9.282b	3.526bc	16.274c	4.169cd
Erdurmuş	4.166a	2.758c	8.538c	3.462bcd	16.858b	4.014d
Gülşeker	3.610c	3.021b	8.578c	3.316cd	13.397c	3.680e
MSI-E	3.588c	2.952b	8.224c	3.270cd	13.014c	3.584e
Smith	3.931b	3.234a	10.123a	3.583bcd	16.966b	4.291bc
Sorge	4.139a	3.291a	10.384a	3.715a	19.431a	4.631a
Tracy	3.660c	2.849c	8.139c	3.254d	13.088c	3.545e
Ulusoy	4.189a	2.675c	8.254c	3.432bcd	16.645b	3.943d
USDA Taiwan	3.350c	2.651c	6.914d	3.001e	10.239d	3.017f
Uzun	4.256a	3.140a	10.040a	3.698ab	19.579a	4.572ab
Average	3.876	2.976	8.848	3.426	15.549	4.545

$p<0.05$

Significant differences were observed between seed varieties in terms of length. The longest seed belonged to "Uzun" variety with an average length of 4.256 mm, while "USDA Taiwan" variety had the shortest seed with 3.350 mm. The average length value of the seeds was determined as 3.876 mm.

In terms of width, "Sorge" variety had the widest seed width with 3.291 mm, while "USDA Taiwan" had the narrowest seed width with 2.651 mm. In general, the average width of the varieties examined was 2.976 mm. The differences in length and width values among the varieties can be explained by the effect of genetic diversity and growing conditions.

The mean arithmetic diameters of the seeds examined in the study also showed significant differences among the varieties. "Sorge" variety had the highest mean arithmetic diameter with 3.715 mm, followed by "Uzun" with 3.698 mm and "Smith" with 3.583 mm. The lowest mean arithmetic diameter value belongs to "USDA Taiwan" variety with 3.001 mm. The average arithmetic diameter value was determined as 3.426 mm in general.

When the average geometric diameter of the seeds was analyzed, "Uzun" variety showed the highest value with 19.579 mm, followed by "Sarge" with 19.431 mm and "Smith" with 16.966 mm. The lowest geometric diameter was recorded in "USDA Taiwan" variety with 10.239 mm. The average geometric diameter value was 15.549 mm.

When the surface area of the seeds was analyzed, it was observed that "Sorge" variety had the highest value with a surface area of 10,384 mm². This was followed by "Uzun" with 10.040 mm² and "Smith" with 10.123 mm². On the other hand, the lowest surface area value was recorded in "USDA Taiwan" variety with 6.914 mm². The average surface area value was determined as 8.848 mm².

When the sphericity ratios of the seeds are analyzed, it is seen that there are significant differences between the varieties. The highest sphericity value belongs to "Sorge" variety with 4.631. This variety is followed by "Uzun" with 4.572 and "Smith" with 4.291. The lowest sphericity value was observed in "USDA Taiwan" variety with 3.017. The average sphericity value was determined as 4.545.

Sarge and Uzun varieties were found to be more prominent among the other seed varieties according to the traits analyzed. USDA Taiwan variety had the lowest values compared to other sugar sorghum varieties.

According to the results obtained from the examination of the seeds of ten different sugar sorghum varieties; it is suggested that sieves with 3-4 mm size can be used for cleaning and classifying the seeds since they have close dimensions to each other.

Germination characteristics of seeds of varieties

Seeds of ten different sugar sorghum varieties germinated under controlled conditions in a BİNDER brand incubator according to ISTA (2007) rules were determined to have approximately 98-99% germination ability. In the study, the seeds were observed and recorded daily. The germination of the seeds lasted for five days and during this period, no substance was used to stimulate the germination of the seeds. In addition, no disease occurrence was observed. The 2022 season sugar sorghum seeds had high germination capacity and did not show any signs of disease, and it was determined that producers can safely use these seeds if they provide appropriate storage conditions.

The germination times of the seeds of Tracy and Ulusoy cultivars were slightly longer than the other cultivars (24 hours-48 hours). On the other hand, it was observed that germination was completed in almost the same time period in other varieties. These results show that Tracy and Ulusoy seeds are slightly slower in germination rate than other varieties, but they can germinate without any problem when provided with a suitable germination environment. According to the data obtained from the seeds of ten different sugar sorghum varieties examined in the study, these seeds can be used efficiently in production.

Conclusions

In this study, some agronomic characteristics of the seeds of ten different varieties of sugar sorghum, a C4 plant that has found its place in many areas from human food to fuel production in recent years, were determined. It is predicted that this plant, which has a high economic return, will show much higher resistance to biotic and abiotic stress conditions with future breeding studies. The absence of any disease symptoms in the ten different varieties of sugar sorghum seeds examined and their germination within the predicted time allows the production of healthy and resistant varieties. In addition, it is thought that it will find a place in the agricultural production spectrum as it will benefit the producers in terms of economic income.

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