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Description of cultivar

Culiacán-09: a new dual-purpose sorghum variety for the state of Sinaloa

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Abstract

The new sorghum variety Culiacán-09 was developed in 2009 at the Valle de Culiacán Experimental Field-National Institute of Forestry, Agricultural, and Livestock Research and registered in the National Catalog of Plant Varieties of the National Seed Inspection and Certification Service with number SOG-651-130423 and breeder's title 3156. This variety adapts to the sorghum-producing areas for the state of Sinaloa; it showed higher yields and is tolerant to the main pests and diseases that affect the crop in the region. Culiacán-09 is an amber-grained variety; it is recommended for irrigation and rainfed conditions; the average yield is 3.92 t ha-1 of grain and 29.6 t ha-1 of fresh forage. Culiacán-09 has better bromatological quality than commercial hybrids in forage, with 7% protein and 77% digestibility, it exceeded commercial hybrids by 26% and 31% on average, respectively. It is tolerant of diseases that are present in the region, such as ergot, anthracnose, panicle blight, and carbonaceous rot of the stem.

Keywords:

forage, genetic improvement, grain, yield.

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Sorghum (*Sorghum bicolor* L. Moench) is a multipurpose crop that is among the five major cereal crops in the world; it is used in the human diet as an ingredient in food and beverages due to its absence of gluten; for animal consumption, it is used as fresh or dehydrated, silage or hayed forage (Ananda *et al*., 2020). In Mexico, the area planted with sorghum in 2023 was 1 506 000 ha, with a production of 4 815 000 t of grain and 3 211 000 t of fresh forage. In this year, the volume of national grain production represented 8.7% of world production, placing Mexico as the fourth global producer (SIAP, 2024).

Sinaloa ranks fourth nationally in terms of both planted area and sorghum production; 43 486 ha were planted in 2023, of this area, on average, 30% are sown with varieties and the rest with commercial hybrids, more than 60% was grown under rainfed conditions in the spring-summer cycle, with a production of 172 538 t of grain sorghum and 53 442 t of forage sorghum (SIAP, 2024). At INIFAP Valle de Culiacán Experimental Field (CEVACU), for its acronym in Spanish, INIFAP's Sorghum Genetic Improvement Program has identified genotypes that stand out for their tolerance to pests and diseases compared to commercial hybrids.

The new variety Culiacán-09 stands out for presenting scale 2 tolerance to ergot caused by *Claviceps africana*, anthracnose caused by *Colletotrichum graminicola*, panicle blight caused by *Fusarium moniliforme*, and carbonaceous rot of the stem caused by *Macrophomina phaseolina*. Disease tolerance was assessed visually in the field, where 1 is the most tolerant genotype and 5 is the most susceptible genotype (Williams *et al*., 2009). In studies carried out in Sinaloa, Culiacán-09 was reported as one of the most tolerant to *Macrophomina phaseolina*, considering it for the formation of parents and hybrids tolerant to *M. phaseolina* (Moreno *et al*., 2017); currently, this variety is being evaluated for its tolerance to the yellow sorghum aphid (*Melanaphis sacchari* Zehntner) and it has been identified to have a certain tolerance to this aphid, which is considered one of the main pests in sorghum crops, which has registered losses between 30 and 100% of commercial lots due to severe aphid infestation (Maya and Rodríguez, 2014).

Registration of the Culiacán-09 variety

It is owned by INIFAP with registration in the National Catalog of Plant Varieties (CNVV), for its initialism in Spanish number SOG-651-130423 and breeder's title number 3156 issued by the National Seed Inspection and Certification Service (SNICS), for its acronym in Spanish in 2023.

Origin

The sorghum variety Culiacán-09 was developed in the Sorghum Genetic Improvement Program of INIFAP CEVACU and was obtained through genetic recombination and selection. The germplasm that gave rise to this new variety was introduced in 1986 to CEVACU; it was from the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). Its progenitor lines were an androsterile female and a male fertility restorer of innate genealogy; the cross was assigned the name BT09T9B. The selection of the segregating material of the cross began from the first generation (F1) and was harvested en masse (M). From the second generation (F2) onwards, selection was carried out individually by panicle, always selecting by panicle size, type of panicle, exertion, height, plant health, and earliness until the fifth generation (F5). From the sixth to the seventh generation (F7), it was harvested in masse and through this process, a homogeneous line was achieved, which gave rise to the Culiacán-09 variety, whose pedigree is: BT09-T9-M-2-5-3-1-M-M.

Varietal description

The description of the variety was made using the descriptors of the International Union for the Protection of New Varieties of Plants (UPOV), for its acronym in Spanish under rainfed and irrigated conditions in the south and center of Sinaloa. In the spring-summer cycle under rainfed conditions, Culiacán-09 behaved with an intermediate vegetative cycle, with 65 to 70 days to flowering and

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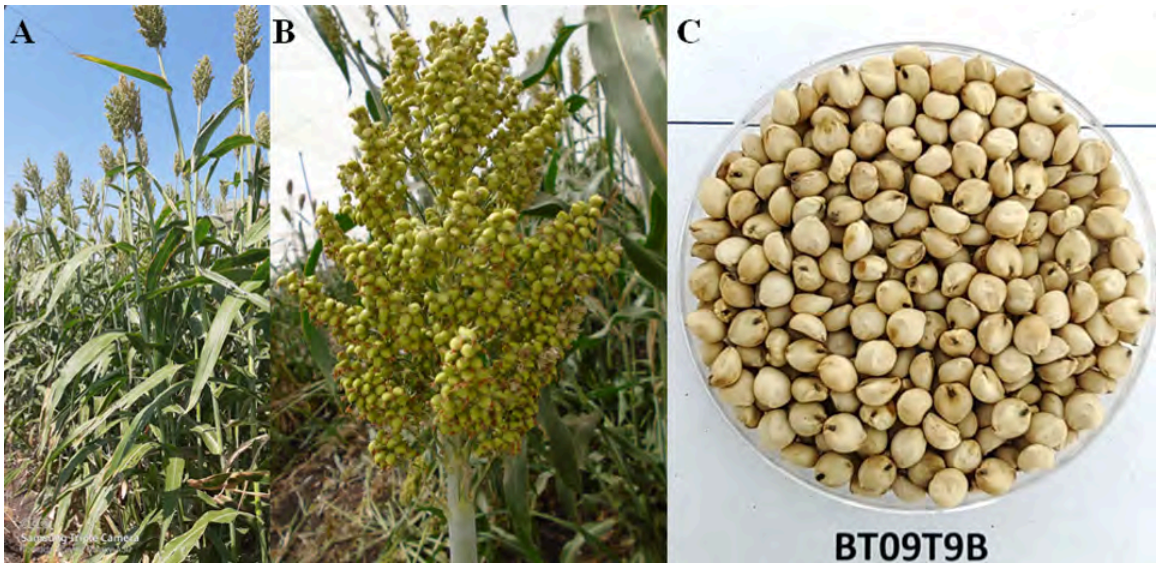
105 to 110 days to harvest. It has a plant height of 3.25 m and its leaves are light green, medium in texture, without anthocyanins (Figure 1A and 1B). Culiacán-09 develops a stem with eight internodes to maturity, the juice extracted from the stem has a high content of soluble solids, which, in the phenological state of milky-doughy grain, ranges between 16 to 17 °Brix. The panicles are medium in size (23 cm), semi-compact, with good exsertion (20 cm) and glumes without anthocyanins in the flowering stage; the grain is amber, elliptical and semi-flattened in shape, with crystalline testa and endosperm and medium in texture (Figure 1C).

Figure 1. Morphological characteristics of the Culiacán-09 variety. A) plant size; B) type and color of panicle and C) color and grain shape.



In yield trials carried out over a period of seven years (2013 to 2019) during the spring-summer cycle under rainfed conditions, Culiacán-09 had average yields of 3.92 t ha-1 of grain, exceeding the average of two commercial controls by 30% (Table 1). For the production of the present variety, it is suggested to use the technological package developed by INIFAP for the state of Sinaloa (Moreno *et al*., 2020).

Table 1. Average grain yield and agronomic characteristics of three sorghum genotypes assessed in seven environments in the state of Sinaloa in the agricultural cycles from 2013 to 2019.

Genotype	Grain yield (t ha^{-1})								Agronomic characteristics				
	2013	2014	2015	2016	2017	2018	2019	Aver	DF	PH	PL	EXS	Forage
Culiacán-09	3.87a	3.95a	3.8a	3.8a	3.97a	4.02a	4.05a	3.92a	68.5a	3.25a	23.2a	20a	29.6a
Milón*	2.77b	2.55b	2.6b	2.55b	2.8b	2.77b	2.8b	2.7b	67a	2.51b	19.2b	18.2a	16.4b
Hegary*	2.75b	2.7b	2.77b	2.65b	2.62b	2.52b	2.47c	2.62b	66a	2.42c	16.7c	17.5a	16.2b
Mean	3.13	3.06	3.05	3	3.13	3.1	3.1	3.08	67.1	2.7	19.7	18.5	20.7
CV (%)	6.4	6.5	6.2	6.4	9.9	8.7	3.9	3.6	3.8	1.6	4.8	8.3	5.09
LSD0.05	0.39	0.39	0.37	0.38	0.61	0.53	0.24	0.22	5.1	0.08	1.89	3.06	2.08

Genotypes with the same letter in a column are statistically the same (Tukey, 0.05). *= commercial controls; Aver= average; DF= days to flowering; PH= plant height (mts); PL= panicle length (cm); EXS= panicle exertion (cm).

During the spring-summer cycles, the production of fresh forage was evaluated in the localities of San Ignacio, Elota, Mazatlán, Concordia, Cósala, and Culiacán in the state of Sinaloa, which were established under rainfed conditions; Culiacán-09 presented an average yield of 30 t ha-1

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of fresh forage,44% higher on average than the yield of the commercial controls (Table 1). The bromatological quality of the forage was 77% digestibility and 7% protein, 30.98 and 25.82% higher, respectively, than the commercial control. Due to its yield characteristics and the bromatological quality of forage, the Culiacán-09 variety is considered to have a dual purpose, whose potential can be used for silage, a strategic forage conservation activity that contributes to the solution of the main problem of rainfed livestock farming in Sinaloa: the lack of forage during the dry season of the year (Hernández *et al*., 2010).

On the other hand, the physical and chemical analysis of the sorghum grains found that the physical dimensions of this variety (length, width, and thickness) were 4.43, 4.07, and 2.8 mm, respectively; it has been reported that the sorghum grains are typically round, though most have a flattened part (Reichert *et al*., 1988); in commercial varieties and hybrids, sorghum grains have been shown to have average values of 4, 2.5, and 2 mm in length, width, and thickness, respectively (Rooney and Serna, 2000). For its part, the weight of 1 000 grains of the Culiacán-09 variety is 39 ±0.26 g. Due to genetic diversity, sorghum grains can vary in shape and size; Rooney and Serna (2000) pointed out that the weight of 1 000 grains of sorghum can vary from 30 to 80 g depending on the cultivar and the climatic conditions where it is grown. The Culiacán-09 variety had a hectoliter weight of 897 ±4.4 g hl-1, above the averages reported by Pérez and Serna (2007), 765 g hl-1 for white sorghum grains. The chemical composition of sorghum grains of the Culiacán-09 variety presents a percentage of protein, lipid, and carbohydrate contents of 14, 4 and 81%, respectively; various studies have reported that sorghum contains a 10-12% protein range and a 3-4% lipid range (Rooney and Serna, 2000), parameters considered to be of quality for the production of animal feed.

Seed availability

Due to the nationwide demand for genotypes tolerant to diseases and drought, INIFAP makes the Culiacán-09 seed available to the general public. Agricultural producers, rural production societies, and seed companies interested in this material can go to the Valle de Culiacán Experimental Field and submit their request for seed needs.

Conclusions

The Culiacán-09 variety is presented as a new alternative to be grown in the state of Sinaloa; it has forage quality and higher grain yield in addition to being an easy seed for farmers to produce, which will generate a significant reduction in production costs.

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