

# VCS TOLEO: New Dual-Purpose Sorghum Variety for Sinaloa, Mexico

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## ABSTRACT

**Objective:** To describe the morphological and agronomic characteristics of VCS TOLEO, a red grain sorghum variety.

**Design/Methodology/Approach:** VCS TOLEO was developed at INIFAP's Valle de Culiacán Experimental Station in 2009 through a pedigree selection breeding process. From 2013 to 2018, it was evaluated in yield trials, and selected for its tolerance to pests, diseases, and high productivity.

**Results:** Based on these evaluations, the VCS TOLEO variety recorded the highest average grain and forage yields.

**Study Limitations/Implications:** The promotion of this variety in the environments of Sinaloa is desirable.

**Findings/Conclusions:** VCS TOLEO showed adaptation to the climatic conditions typical of the region.

**Keywords:** Variety, Sorghum, Yield.

## INTRODUCTION

Sorghum (*Sorghum bicolor* L. Moench) is a multipurpose crop and ranks among the top five cereal crops in the world (Ananda *et al.*, 2020). It is used in human nutrition as an ingredient in food and beverages due to its gluten-free nature, and in animal feed as fresh or dehydrated forage, silage, or hay. In Mexico, the sorghum planting area in 2023 was 1.506 million hectares, with a production of 4.815 million tons of grain and 3.211 million tons of green forage. That year, Mexico's national grain production represented 8.7% of global

production, placing the country as the fourth-largest producer worldwide (SIAP, 2024). Sinaloa ranked fourth nationally in both sorghum planted area and production. In 2023, 43,486 hectares were sown, of which approximately 30% were planted with varieties and the rest with commercial hybrids. More than 60% of the area was cultivated under rainfed conditions during the spring-summer season, producing 172,538 tons of grain sorghum and 53,442 tons of forage sorghum (SIAP, 2024). However, the extreme conditions caused by climate change are a constant threat that currently limits production. The main challenges for sorghum cultivation in the state include the use of genotypes susceptible to pests and diseases, the dispersion of rainfed sowing areas, and rainfall variability. Therefore, there is a need for new sorghum varieties and hybrids with higher yield potential and improved tolerance to the main pests and diseases affecting the crop.

## **MATERIALS AND METHODS**

### **Origin**

The VCS Toleo sorghum variety was developed from heterogeneous lines provided by the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). The parental lines consisted of a male-sterile female and a male fertility restorer with innate pedigree. The F1 generation was produced in 2009 through hybridization and pedigree selection at INIFAP's Sorghum Breeding Program at CEVACU. The F1 population was mass harvested (M) in 2009 and designated as BT09-T5. From the F2 to the F5 generations (2010-2011), individual plant selection was conducted using the panicle-to-row or pedigree method, based on panicle size and type, exertion, plant height, health, and earliness. From F6 to F7 (2012), mass selection was carried out, resulting in the development of a homogeneous line that gave rise to the VCS Toleo variety, with the pedigree: BT09-T5-M-2-5-3-1-M-M.

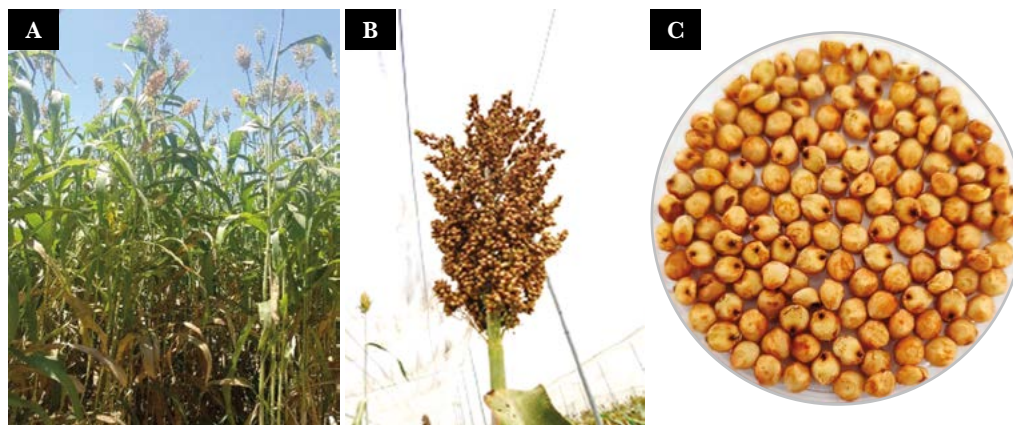
### **Trait evaluation**

The varietal description was conducted from 2013 to 2015 during the spring-summer season under rainfed conditions, following the descriptors from the International Union for the Protection of New Varieties of Plants (UPOV) TG/122/4. The phenotypic characterization of these lines was carried out according to the UPOV sorghum descriptors (UPOV, 2015).

VCS Toleo is a medium-maturity variety, with 65 days to flowering and 105 to 110 days to harvest. Plant height averages 3.04 m. Leaves are light green, of medium texture, and anthocyanin-free (Figure 1A). At maturity, the stem presents an average of 10 internodes. Soluble solids content at the milky-dough grain stage ranges from 12 to 14 °Brix. The panicle is medium in size, 23.3 cm long, semi-compact, with 20.1 cm exertion. The grain is reddish-orange, elliptically broad, and semi-flattened in shape (Figure 1B and C).

### **Evaluated variables**

Days to flowering (DF), Plant height (PH), Panicle length (PL), Panicle exertion (PEX), Grain yield in tons per hectare adjusted to 14% moisture, and Green forage yield in tons per hectare.



**Figure 1.** Morphological characteristics of the VCS Toleo variety. A) Plant structure at flowering, B) Panicle type and color, C) Grain color and shape.

### Statistical analysis

A combined analysis of variance (ANOVA) was conducted to evaluate the main effects of genotype (G) and environment (E) using the following model:

$$Y_{ijk} = \mu + G_i + E_j + (GE)_{ij} + R_k(E_j) + E_{ijk}$$

where  $Y_{ijk}$  = mean yield of the  $i$ -th genotype in the  $j$ -th environment and  $k$ -th replication;  $\mu$  = overall mean effect;  $G_i$  = effect of the  $i$ -th genotype;  $E_j$  = effect of the  $j$ -th environment;  $(GE)_{ij}$  = interaction effect between the  $i$ -th genotype and the  $j$ -th environment;  $R_k(j)$  = effect of the  $k$ -th replication within the  $j$ -th environment; and  $E_{ijk}$  = random error associated with the  $i$ -th genotype,  $j$ -th environment, and  $k$ -th replication, based on the additive linear model.

Data were analyzed using SAS statistical software (SAS, 2006). Mean comparisons of agronomic traits were performed using the LSD test ( $p \leq 0.05$ ).

### RESULTS AND DISCUSSION

The average grain and green forage yields over six years of evaluation were  $3.07 \text{ t ha}^{-1}$  and  $36.1 \text{ t ha}^{-1}$ , respectively (Table 1). The forage showed 73.08 % digestibility and 6.22% protein, superior to the commercial controls with averages of 52.78% digestibility and 5.64% protein.

The new variety VCS Toleo stands out for its tolerance to diseases such as ergot (*Claviceps africana*), anthracnose (*Colletotrichum graminicola*), sorghum head blight (*Fusarium moniliforme*) and charcoal rot of the stem (*Macrophomina phaseolina*). In recent evaluations, VCS Toleo exhibited tolerance to the sorghum yellow aphid (*Melanaphis sacchari* Zehntner) at level 3, based on the scale previously reported for this aphid (Sharman *et al.*, 2013), considered one of the main pests in sorghum cultivation that causes losses of 30% to 100% in commercial fields due to severity of infestation levels (Maya & Rodríguez, 2014).

**Table 1.** Agronomic characteristics and average grain and forage yields of four sorghum genotypes evaluated over six years in the state of Sinaloa.

Genotype	Grain yield per year (t ha <sup>-1</sup> )						Average		Agronomic characteristics			
	2013	2014	2015	2016	2017	2018	Grain (t ha <sup>-1</sup> )	Forage (t ha <sup>-1</sup> )	DF	PH	PL	PE
VCS Toleo	3.2a	3.0a	3.2a	2.9a	3.0a	2.9ab	3.0	36.1a	65.2a	3.0a	23.3a	20.1a
Milón <sup>†</sup>	2.7bc	2.8ab	2.8b	2.8a	2.5b	2.7b	2.7	24.1b	66.0a	2.6b	17.5b	18.5a
Hegary <sup>†</sup>	3.1ab	2.5b	2.7b	3.0a	2.9a	3.1a	2.9	23.6b	63.7a	2.4c	16.2c	18.7a
Silomiel <sup>†</sup>	2.6c	3.0a	2.9ab	2.8a	2.7ab	2.8b	2.8	26.0b	63.0a	2.4c	18.0b	18.0a
Media	2.9	2.8	2.9	2.9	2.8	2.9	2.8	27.4	64.5	2.6	18.8	18.8
CV (%)	6.1	4.6	5.3	7.8	5.8	5.1	5.8	7.5	3.0	1.6	3.1	15
DMS 0.05	0.3	0.2	0.3	0.4	0.3	0.3	0.3	4.3	4.0	0.1	1.2	5.9

<sup>†</sup> Commercial checks. Genotypes with the same letter within a column are statistically similar (LSD, 0.05). DF: Days to Flowering, PH: Plant Height (m), PL: Panicle Length (cm), PE: Panicle Exertion (cm).

## CONCLUSIONS

VCS Toleo is a dual-purpose sorghum alternative with production capacity in the dry tropics of Mexico, including the states of Sinaloa, Nayarit, Jalisco, Tamaulipas, Colima, and Michoacán. Its seed is adapted to the climatic conditions of Sinaloa, such as temperatures of 35-40 °C, relative humidity of 40-80% with summer rains, and an average precipitation of 700 mm, an amount considered minimum for rain-fed agriculture. The variety VCS Toleo was registered in the National Catalogue of Plant Varieties (Catálogo Nacional de Variedades Vegetales, CNVV) under number SOG-320-270923 and breeder's title number 3348 issued by the National Seed Inspection and Certification Service (Servicio Nacional de Inspección y Certificación de Semilla, SINCS) in 2023.

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