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Guerrero 31, variety of white seed sesame (*Sesamum indicum* L.)

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ABSTRACT

Objective: To describe the sesame variety *Sesamum indicum* L. Guerrero 31 according to UPOV guidelines and to evaluate its performance across three environments in the South Pacific region of Mexico.

Design/methodology/approach: Guerrero 31 was developed via mass selection based on plant type and grain color. Its varietal description followed the UPOV Distinctness, Uniformity, and Stability (DUS) guidelines. Field trials were conducted using a randomized complete block design with three replications. Data were collected from five central row plants to record the number of capsules per plant, seed weight per plant, and grain yield (kg ha^{-1}). A combined ANOVA, correlation analysis, and mean comparisons were performed (Tukey, $p<0.05$).

Results: Guerrero 31 is a monopodial sesame variety with high pubescence on stems, flowers, and capsules. It flowers at 60 days and matures at 110 days, reaching 160-200 cm in height, with white seeds. It demonstrates moderate tolerance to *Cercospora* spp., *Phoma* spp., and *Diabrotica* spp. Guerrero 31 outperformed three control varieties across environments, yielding 1,120 kg ha^{-1} an increase of 21.61%.

Limitations/implications: To maintain genetic purity, Guerrero 31 should be planted at least 500 m away from other sesame varieties. Weed control, timely fertilization, and integrated pest management are essential during early development to achieve optimal yield.

Findings/conclusions: Guerrero 31 is a new, high yielding sesame variety adapted to altitudes from 17 to 750 m. It is registered in the National Catalogue of Plant Varieties (CNVV) under number AJN-009-190924, with breeder title No. 3514.

Keywords: *Sesamum indicum* L., open-pollinated sesame, white seed, high yield.

INTRODUCTION

Sesame (*Sesamum indicum* L.) is a diploid species (2n=26), primarily self-pollinating, though cross-pollination ranges from 5% to 68% due to pollinating insects (Tripathy *et al.*, 2019). Its seeds are a significant source of nutrients, composed of approximately 25% protein, 46% oil, 7% carbohydrates, 2% fiber, and various minerals (Gadade *et al.*, 2017;

Tzen, 2021). Thus, it is often referred to as the "queen of oilseeds." Additionally, it contains antioxidants such as sesamin and sesamolin, which provide notable health benefits (Wei *et al.*, 2017).

Sesame is cultivated in tropical and subtropical regions worldwide due to its tolerance to drought, high temperatures, and low soil fertility. Global annual production exceeds 6 million tons, with Sudan, Myanmar, India, and China being the largest producers. Mexico ranks 18th (FAO, 2019). The main producing states in Mexico are Guerrero (12,000 tons), Michoacán (8,000 tons), Oaxaca (5,500 tons), Sinaloa (5,200 tons), and Chiapas (3,700 tons), with smaller contributions from other states. However, annual domestic demand reaches 80,000 tons, requiring the import of approximately 44,000 tons to meet consumption needs (SIAP, 2024).

Regarding the use of improved varieties, Pakistan cultivates the TH-6 variety, which yields an average of 2,217 kg ha^{-1} and has shown a 32.16% increase in yield compared to the control TS-3 (Anwar *et al.*, 2013). In Venezuela, the UCLA-2 variety has a potential yield of 1,246 kg ha^{-1} and performs 28.41% better than commercial cultivars (Laurentin, 2017). In contrast, Mexico offers improved varieties that were released over two decades ago, with yields ranging from 738 to 937 kg ha^{-1} (Joaquín, 2003). However, for various reasons, these varieties are no longer present in the market. As a result, sesame producers have voiced their interest in accessing varieties with higher yield, productivity, pest and disease resistance, and good grain quality (Vásquez-Ortiz *et al.*, 2025). Consequently, efforts to improve sesame breeding have intensified in the state of Guerrero.

There are various methods of genetic improvement, including mass selection, which involves selecting and recombining individual plants from a population. The main feature of this method is that selection is based on the phenotype of individual plants, without replication. Therefore, its success depends on proper crop management, the high heritability of the trait, and, crucially, a broad genetic base. It is also more cost effective compared to other methods (Solares and Gómez, 2012). According to statistics, mass selection provides a genetic gain of approximately 3.5% per year (Santacruz, 2023). It is considered an efficient recurrent selection method and is used in self-pollinating species (Benítez-Riquelme, 2002). However, it is essential to visually assess the different generations of progeny to eliminate poor or defective plants, as well as those with excessive segregation. Subsequently, yield trials with replications and control varieties should be conducted (Angulo and Ortiz, 2020).

In sesame genetic improvement, the primary trait of interest is grain yield, which is a quantitative trait highly influenced by the environment (Vinoth *et al.*, 2018). Its expression results from the interaction of several traits, including the number of capsules per plant and seed weight per plant, among others (Ujjainkar *et al.*, 2022). It is also necessary to identify which variables are most closely related to yield (Vinoth *et al.*, 2018). Additionally, environmental factors play a significant role in the variability and expression of phenotypic traits (Acevedo *et al.*, 2019). Therefore, genotypes and traits must be evaluated across multiple environments to understand the effects of genotype, environment, and their interaction, and to identify genotypes with superior performance either across diverse environments or in specific ones (Yan *et al.*, 2000).

In this context, evaluations were conducted on sesame populations, including landraces, improved, and introduced varieties. Among them, several outstanding materials were identified, particularly population 31, which demonstrated yields of up to 1,600 kg ha^{-1} under experimental conditions, plant health, and larger seed size compared to existing varieties. Consequently, it was selected for further breeding and was eventually named Guerrero 31. The new sesame variety, Guerrero 31, surpasses control varieties in both yield and grain quality across various regions of the South Pacific. Therefore, the aim of this study was to describe the improved variety Guerrero 31 based on UPOV guidelines and to evaluate its performance in sesame producing regions.

MATERIALS AND METHODS

Genetic selection

At the Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias (INIFAP), Campo Experimental Iguala, genetic improvement of sesame was carried out using local populations. Population 31 was identified as outstanding due to its superior grain yield (Toledo-Aguilar *et al.*, 2024). This population was originally collected in the community of Tejas Crudas, municipality of Cuajinicuilapa, Guerrero. Through mass selection based on plant type and seed color, it gave rise to the variety Guerrero 31.

Establishment and crop management

Population 31 was sown during the 2020 spring-summer (SS) growing cycle by placing seeds along the shoulder of the furrow and covering them with a thin layer of soil. At 30 days after sowing (DAS), plant density was adjusted to two to three plants per hill, achieving a density of 62,500 plants ha^{-1}. Agronomic management followed the procedures described by Toledo-Aguilar *et al.* (2024) and Vásquez *et al.* (2014), with modifications to fertilization: 30N-20P-00K, consisting of ammonium sulfate diluted (10 kg in 200 L of water) applied at the stem base at 25 and 60 DAS, plus 125 g of bokashi-type compost per plant. Weed control was performed manually with hoes and mechanically by inter row cultivation. Pest and disease control used low environmental impact products, including *Metarhizium anisopliae*, *Bacillus thuringiensis*, and *Trichoderma* spp. Harvesting was done manually when the first capsules began to open.

Genetic improvement

The positive mass selection method was used, involving the selection of plants with uniform flowering and height, absence of branching, minimal damage from *Cercospora* spp. and *Phoma* spp. (which cause leaf and capsule spotting), and *Fusarium* spp. (which causes stem constriction). Plants with low infestation by *Diabrotica* spp., absence of viral symptoms, resistance to lodging, and white seed color were also selected. Undesirable individuals were removed from the population, and the remaining plants were bulked to form a composite population (SS 2020 cycle).

During the SS 2021 cycle, 800 plants from the composite population were sown. 30 DAS, 200 plants with reduced vigor, smaller size, or lodging before flowering were removed. Mass selection continued, and 500 plants were selected based on the same desirable traits identified in the previous cycle. A balanced composite was then formed using 15 g of seed per selected plant for the next generation. Subsequently, 1,650 plants from this composite were sown, and at 30 DAS, 650 low vigor and undersized plants were removed. Mass selection was repeated, and 1,000 plants were selected based on health and seed color. Seeds from these selected plants were combined to form a balanced composite (SS 2022 cycle).

Yield trial

The genetic material tested was the Guerrero 31 variety, with three local landraces used as controls each cultivated by producers in their respective regions. Due to budget constraints, only three contrasting environments from five sesame producing states were selected. These locations had suitable soils and slopes of less than 5%, and included: Iguala Experimental Station, Guerrero (18° 20' N, 99° 30' W; 750 m); Campo Experimental Rosario Izapa, Chiapas (14° 58' N, 92° 09' W; 443 m); and the Sitio Experimental Costa de Oaxaca, Oaxaca (15° 59' N, 97° 25' W; 17 m). Climatic data (monthly temperature and rainfall) for the evaluation of environments were obtained from the National Meteorological Service (CONAGUA, 2023) (Figure 1).

Experimental design

In each evaluation environment, genotypes were arranged in a randomized complete block design (2×2; blocks×genotypes) with three replications. Each experimental plot measured 12 m^2 and consisted of three 5.0 m long rows, spaced 0.8 m apart, with 0.5 m between hills. Sowing was manual, with seeds placed along the shoulder of the furrow and lightly covered with soil. 30 DAS, plant density was adjusted to two to three plants per hill (25 plants per 5.0 m row and 75 plants per plot), resulting in a density of 62,500 plants ha^{-1}. Agronomic management followed the protocol proposed by Toledo-Aguilar *et al.* (2024) and Vásquez *et al.* (2014), with slight modifications. Data were collected from five central row plants and included the number of capsules per plant, seed weight per plant (g), measured using a digital precision balance, and grain yield estimated in kg ha^{-1}.

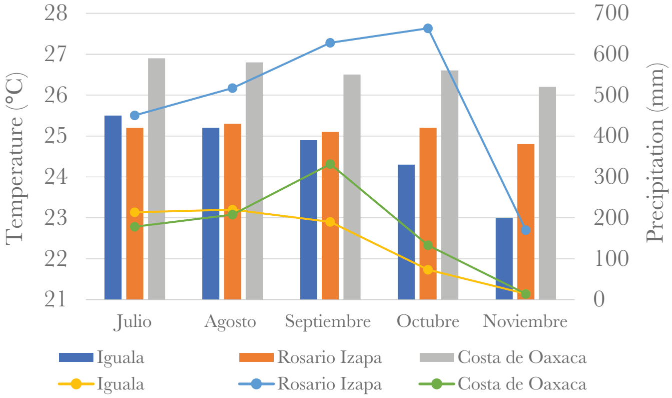

Figure 1. Monthly mean temperature and cumulative monthly precipitation in the sesame genotype evaluation environments of the South Pacific region of Mexico.

Statistical analysis

In the combined analysis of variance, environment effects were considered random, and genotype effects were considered fixed. Variance components, residuals, and the coefficient of variation were estimated using a mixed-effects linear model (Alvarado *et al.*, 2020). The Wald statistics were applied at a significance level of $p \leq 0.05$. A graphical analysis of the genotype by environment interaction was performed for grain yield (Tukey, 0.05), along with a correlation analysis among variables. All analyses were conducted using SAS software version 9.2 (SAS, 2012).

Varietal description

To characterize the Guerrero 31 variety, the crop was established during the SS 2023 cycle in two environments: one at the Campo Experimental Iguala and the other on a farmer's field in the community of Zicapa (17° 58' N, 99° 03' W; 860 m), municipality of Copalillo, both located in Guerrero. The varietal description was conducted using the Test for Distinctness, Uniformity, and Stability (DUS) for sesame (UPOV, 2013).

RESULTS AND DISCUSSION

Varietal description

Guerrero 31 is an open-pollinated variety developed through mass selection based on plant type, health, and seed color. It is a monopodial variety (single stem) with high pubescence on the stem, flowers, and capsules. Flowering occurs at 60 days, and it is considered late maturing, reaching maturity at 110 days. It produces one to three green capsules per axil and has a plant height ranging from 160 to 200 cm. The variety produces white seeds and an average yield of 1,120 kg ha^{-1} (Table 1; Figure 2). Guerrero 31 features a strong root system that confers resistance to lodging. It also shows moderate tolerance to viral diseases, leaf spots caused by *Cercospora* spp. and *Phoma* spp., and damage from *Diabrotica* spp. Additionally, its dense foliage suppresses weed growth and facilitates harvesting.

Genotype performance across environments

The combined analysis of variance revealed significant differences ($p \leq 0.01$) in variables associated with sesame grain yield for the factor's environment, genotype, and genotype by environment interaction (Table 2). This suggests potential yield variation across environments, likely influenced by climatic conditions during crop development (Baraki *et al.*, 2020). Therefore, precipitation and temperature data were collected to assess their effect on genotype performance. In the Costa de Oaxaca environment, the average monthly temperature was 2.02 °C higher compared to the other two environments. Meanwhile, Rosario Izapa recorded 1,716.4 mm of rainfall during the growing cycle, followed by Costa de Oaxaca with 1,562.9 mm. These values represent 241.17% and 219.60% more rainfall, respectively, compared to Iguala (Figure 1). Both temperature and the amount and distribution of rainfall during the evaluation period may explain environmental variability. According to Li *et al.* (2019), intense rainfall can have both positive and negative effects on crop yields. For example, they observed a 17% reduction in maize yield under heavy

Table 1. Varietal description of Guerrero 31 based on UPOV guidelines, evaluated in Iguala and Zicapa, Guerrero, during the 2023 SS rainfed cycle.

No.	Descriptor	Characteristic	Score	Observations
1	Plant: Growth type	Determinate	2	Growth ends in flowering
2	Stem: Number of nodes to first flower	High	7	More than 10 nodes
3	Stem: Pubescence	Medium	2	None
4	Stem: Length	Long	7	Average of 60 cm
5	Lamina: Length	Long	7	Average of 20 cm
6	Lamina: Width	Medium	5	Average of 16 cm
7	Lamina: Length to width ratio	Medium	5	Average index of 1.3
8	Lamina: Degree of lobing	Weak	3	The first third of the plant shows weak to moderate lobed leaves
9	Lamina: Green color intensity	Dark	7	Strong
10	Petiole: Length	Medium	5	Average of 12 cm
11	Floral Stem: Number of flowers per leaf axil	One	1	Located in the central part of the plant
12	Floral Stem: Nectaries	Present	9	Pale yellow
13	Flower: Main corolla Color	Pink	3	Does not cover the entire area
14	Flower: Intensity of pink color on outer side of corolla	Medium	2	Does not cover the entire surface
15	Flower: Intensity of pink color on inner side of lower lip	Dark	3	Clearly marked
16	Flower: Corolla pubescence	Strong	3	Clearly visible
17	Capsule: Number of carpels	Two	1	None
18	Capsule: Length	Medium	5	Average of 3.4 cm
19	Capsule: Width	Medium	5	Average of 1 cm
20	Capsule: Pubescence	Strong	3	Clearly marked
21	Capsule: Color	Green	1	Dark
22	Seed Coat: Color	White	1	Slightly creamy
23	Seed Coat: Texture	Smooth	1	Even surface
24	Time of flowering onset	Late	7	Average of 60 days
25	Time of maturity	Late	7	Average of 110 days
26	Yield	Medium		1,120 kg ha^{-1}

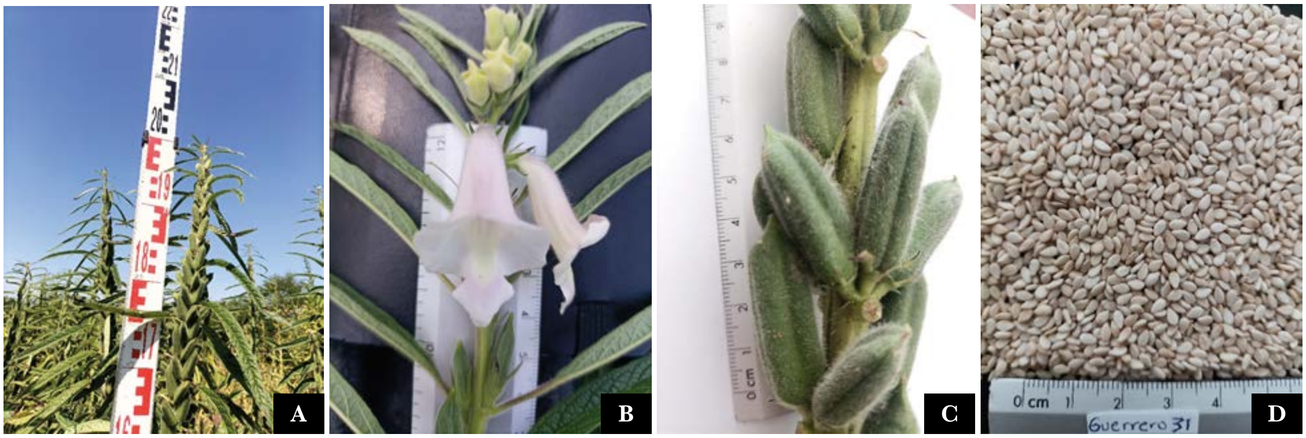

Figure 2. Key characteristics of the Guerrero 31 variety. A: Monopodial growth habit (single stem), medium stem pubescence, weak leaf blades lobing, and dark green color. B: One flower per leaf axil, strong corolla pubescence, and pink coloration. C: Strong pubescence and green color in the capsule. D: White seed (slightly creamy) with a smooth texture. Campo Experimental, Iguala, Guerrero, Mexico.

Table 2. Mean squares from the combined ANOVA across three environments for yield components in sesame, conducted in the South Pacific region of Mexico during the 2023 SS rainfed cycle.

Source of variation	Degrees of freedom	Number of capsules per plant	Seed Weight per plant (g)	Grain yield (kg ha^{-1})
Environment	2	757081.33**	17303.38**	14239763.21**
Replication/Environment	5	19893.06**	574.85**	648593.92**
Genotypes	3	19607.25**	234.51**	439829.10**
Genotype-Environment	6	8585.74**	156.61**	234844.59**
Residual	168	1536.73	28.21	8864.82
Coefficient of Variation (%)		11.43	17.62	20.31
Mean		62.75	19.25	938.75

**significance a $p \leq 0.01$.

rainfall compared to normal conditions, with potential worsening depending on intensity. High temperatures also have adverse effects on plants, thereby reducing crop productivity (Fischer, 2021).

Considering that environmental diversity directly affects crop performance, it was expected that the grain yield of the evaluated genotypes would vary across the testing environments (Figure 3). This variation confirms the presence of genotype by environment interaction. Guerrero 31 stood out in all three environments, with an average yield of 1,120 kg ha^{-1} 16.18% higher than the overall mean (Table 2). This increase may be attributed to sesame's optimal genetic expression under temperatures of 24-26 °C and rainfall between 600 and 900 mm (Toledo-Aguilar *et al.*, 2024), conditions closely met in Iguala. In contrast, Costa de Oaxaca presented average temperatures above 26 °C, and Rosario Izapa received 241.17% more rainfall during the evaluation period. Guerrero 31 was developed in Iguala, which may offer it a local adaptation advantage. Moreover, it consistently outperformed the three landrace genotypes, likely due to its improved genetic background, while the landraces showed greater plant heterogeneity. However, it was not compared to the improved varieties released over two decades ago in Guerrero, which have limited market presence and yields ranging from 738 to 937 kg ha^{-1} (Joaquín, 2003).

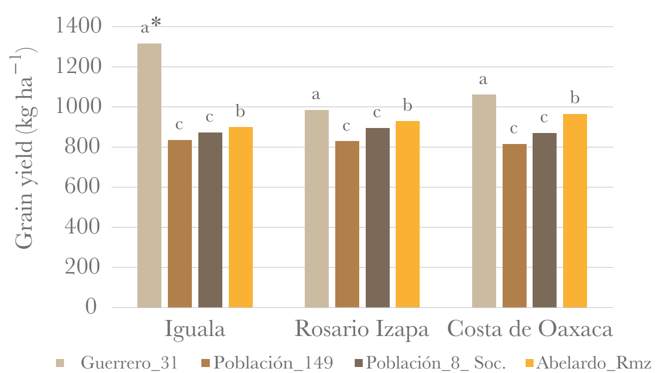

Figure 3. Average grain yield of the Guerrero 31 variety and three local landraces across three evaluation environments in the South Pacific region of Mexico. *Bars not sharing the same letter are statistically different ($p<0.05$).

These results highlight Guerrero 31's average yield advantage of 21.61% over landrace genotypes (Figure 3). Similarly, Anwar *et al.* (2013) in Pakistan reported a 32.16% yield increase with the TH-6 variety over the TS-3 control, and in Venezuela, Laurentin (2017) found that UCLA-2 yielded 28.41% more than commercial cultivars.

Correlation among agronomic variables

The correlation analysis indicated a strong relationship between the number of capsules per plant and seed weight per plant, and a weaker but still positive relationship with grain yield. Both variables had a positive impact on yield (Table 3). Therefore, these traits were important in the evaluation and selection of the Guerrero 31 variety. Similar results were found by Vinoth *et al.* (2018), who reported a significant positive association between number of capsules per plant and grain yield per plant, indicating their major contribution to perhectare yield. In this context, Baraki *et al.* (2020) states that such agronomic traits are critical in the development of high yielding sesame varieties.

Table 3. Correlation matrix of variables associated with sesame grain yield in the South Pacific region of Mexico during the 2023 SS rainfed cycle.

Variables	Number of capsules per plant	Seed weight per plant (g)	Grain yield (kg ha^{-1})
Number of capsules per plant	1.00	0.72	0.33
Seed weight per plant (g)	0.72	1.00	0.46
Grain yield (kg ha^{-1})	0.33	0.46	1.00

Varietal purity

To maintain varietal identity, Guerrero 31 should be sown in isolated plots (at least 500 m from other improved varieties or local sesame populations with open pollination). Off type plants must be removed, followed by seed harvesting and formation of a balanced composite for sowing in the next cycle. Guerrero 31 was registered and released in October 2024. It is listed in the National Catalogue of Plant Varieties (NCPV) under registration number AJN-009-190924 and holds breeder's title No. 3514, dated December 6, 2024. Basic seed is maintained at the Campo Experimental Iguala.

CONCLUSIONS

The varietal description of Guerrero 31 supported its registration in the NCPV of SNICS as an open-pollinated, tall variety with a single stem, high pubescence on flowers and capsules, late maturity, and white seed. Environmental evaluations confirmed its adaptability across altitudes from 17 to 750 m and an average yield of 1,120 kg ha^{-1} 21.61% higher than that of local landraces.

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AGRO PRODUCTIVIDAD