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Description of cultivar

Rincón Grande: a variety of black beans for Veracruz and Chiapas

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Abstract

Diseases, drought, and soil acidity are the main factors reducing bean yields in Chiapas and Veracruz, Mexico. To help solve this problem, the National Institute of Forestry, Agriculture, and Livestock Research developed the new variety of small-grained opaque black beans called Rincón Grande. This was obtained from selections of the Jamapa Plus and XRAV-187-3 cross. Rincón Grande has a cycle of between 85 and 90 days from sowing to harvest and stands out for its high yield (>2.2 t ha^{-1}), resistance to rust, anthracnose and common mosaic, as well as tolerance to golden yellow mosaic. It is a variety with wide adaptation and yield stability in the tropical and subtropical areas of Veracruz and Chiapas. In 2020-2021, it was validated in producers fields in Veracruz, confirming its high productive potential. Rincón Grande has the characteristics of the type of beans demanded by consumers in southeastern Mexico.

Keywords:

Phaseolus vulgaris L., adaptation, disease resistance, yield.

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Importance of the cultivar

In Mexico, black beans represent the commercial type with the highest production, with 35.4% of the national total, followed by pinto beans with 27.6% (FIRA, 2023). In the southeast of the country, Chiapas and Veracruz stand out as the largest producers of small, opaque black beans, being the preferred type by consumers in the region.

The joint average yield of Veracruz and Chiapas is 700 kg ha^{-1}, lower than the national average of 750 kg ha^{-1} (SIAP, 2022). This is mainly due to terminal drought, soil acidity (Tosquy-Valle *et al*., 2014; 2020), and the incidence of fungal diseases, such as rust [*Uromyces appendiculatus* var. *appendiculatus* (Pers.) Unger], angular leaf spot [*Phaeoisariopsis griseola* (Sacc.) Ferraris], and anthracnose [*Colletotrichum lindemuthianum* (Sacc. and Magnus) Lams. Scrib.], and viral diseases, such as golden yellow mosaic and common mosaic (Villar-Sánchez *et al*., 2003; Garrido-Ramírez *et al*., 2020).

This situation is more critical because landraces and improved varieties, such as Negro Jamapa, Negro Medellín, and Verdín, grown in these states are susceptible to one or more of these limiting factors. To address this problem, between 2007 and 2021, INIFAP bean program for southeastern Mexico generated the new variety called Rincón Grande, with high yields, resistant to rust, anthracnose, and common mosaic, tolerant to golden yellow mosaic, and adapted to the soil and humidity conditions prevalent in the tropical areas of Veracruz and Chiapas.

Origin and method of obtaining

The Rincón Grande variety originated from the simple cross between Jamapa Plus and XRAV-187-3 carried out in 2007 at the Bajío Experimental Field (CEBAJ), for its acronym in Spanish of INIFAP. The Jamapa Plus line was derived from the Negro Jamapa variety, selected for its adaptation to the tropics and commercial acceptance of opaque black grain. The XRAV-187-3 line was derived from the XRAV-40-4 opaque black variety, developed by the University of Puerto Rico, which is resistant to the bean golden yellow mosaic virus (BGYMV) and the bean common mosaic virus (BCMV) because it possesses the *bgm-1* and *I* genes (Beaver *et al*., 2014). During 2009, mass selection was carried out in F_2 and F_3 at CEBAJ and in 2010, mass compound in F_4 and F_5 at the Cotaxtla Experimental Field (CECOT), for its acronym in Spanish, Medellín, Veracruz.

Selection was carried out under pressure from the natural incidence of fungal and viral diseases. In 2011, individual selections were made based on their yield and health at CECOT to derive selected F_{5-6} lines and from 2012 to 2013, mass compound in F_7 and F_8 in Rincón Grande, Orizaba, Veracruz under pressure from natural incidence of rust. In each generation of selection, only healthy plants were harvested. From this process, the Jamapa Plus/XRAV-187-3-1-2 F_8 line was generated, which gave rise to the new variety named Rincón Grande.

Phenotypic and agronomic characteristics

Rincón Grande presents plants of indeterminate growth habit, shrubby and erect type II, with short vines and average height of 45.9 cm. Its leaves are green of medium intensity, flowers are violet, and pods are yellow at physiological maturity and a color similar to straw at harvest. It flowers 42 days after sowing, reaches physiological maturity at 76 days, and is harvested between 85 and 90 days. It is resistant to rust, anthracnose, and BCMV and tolerant to BGYMV (Anaya-López *et al*., 2018; Garrido-Ramírez *et al*., 2020). It has wide adaptation in the tropical and subtropical areas of Veracruz and Chiapas as well as high yield potential (>2.2 t ha^{-1}).

Yield assessment in different environments in Veracruz and Chiapas

Rincón Grande was compared with Negro Comapa (N. Comapa) and Negro Grijalva (N. Grijalva) in adaptation nurseries during 2015-2016 in seven environments in Veracruz and one in Chiapas

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that included the following localities: A1: rainfed in Orizaba, Veracruz (altitude 1248 m); A2 and A11: residual moisture in Medellín, Veracruz (altitude 22 m); A3 and A12: residual moisture in Tlapacoyan, Veracruz (altitude 88 m); A4: residual moisture in acidic soil in Juan R. Clara, Veracruz (altitude 133 m); A5: residual moisture in acid soil with dolomite lime in Juan R. Clara, Veracruz (altitude 133 m); A6: residual moisture with drought (D) in Ocozocoautla, Chiapas (altitude 795 m) and A7: terminal drought in Medellín, Veracruz (altitude 22 m).

The overall average yield of Rincón Grande in the evaluation environments (1 281.3 kg ha^{-1}) was significantly higher than that of N. Comapa (1 074.9 kg ha^{-1}) and N. Grijalva (980.3 kg ha^{-1}) according to Student t-test (0.05). Under rainfed conditions (A1), the yield of Rincón Grande was equal to that of N. Comapa and 25.3% higher than that of N. Grijalva. In residual moisture (A2 and A3), it exceeded them by 8.1 and 22.4%, respectively, and in residual moisture and acidic soil (A4), it yielded 36.1 and 29.2% more than the controls in the order cited.

In residual moisture and acidic soil with dolomite lime (A5), Rincón Grande was 21.4 and 19.9% higher than N. Comapa and N. Grijalva, in that order. Under terminal drought (A6 and A7), it also showed advantages of 76.1 and 323.7%, respectively. In general, the average yield of Rincón Grande was 19.2% higher than that of N. Comapa and 30.7% higher than that of N. Grijalva. It is important to note that the N. Comapa and N. Grijalva varieties were used as controls for their high yield potential, wide adaptation, and tolerance to diseases.

Uniform tests were established between 2016 and 2017 in the following test locations: A8: rainfed in acidic soil in Villaflores, Chiapas (altitude 660 m); A9: residual moisture in Ocozocoautla, Chiapas (altitude 597 m); A10: residual moisture in Orizaba, Veracruz (altitude 1 248 m); A13: residual moisture with terminal drought (TD) in acidic soil in Juan R. Clara, Veracruz (altitude 133 m); A14: irrigation in Medellín, Veracruz (altitude 22 m) and A15: irrigation and terminal drought in Medellín, Veracruz (altitude 22 m).

In these localities, the general average yield of Rincón Grande was 1 658 kg ha^{-1}, whereas that of N. Comapa and N. Grijalva was 1 558.4 and 1 615.9 kg ha^{-1}, respectively. Under rainfed conditions and strongly acidic soil (A8), Rincón Grande obtained more than 20% yield than the controls. In residual moisture (A9 to A13), the three varieties had similar yields, except in Ocozocoautla, Chiapas with slightly acidic pH (A9), where Rincón Grande yielded 29.1 and 17% less than the controls.

This behavior suggests that Rincón Grande has better adaptation to acidic soils, whereas the controls have better adaptation to soils close to neutrality (pH> 6). Under irrigation (A14), Rincón Grande surpassed N. Comapa by 15.6% and had a production similar to that of N. Grijalva, while under irrigation and terminal drought (A15), it exceeded both varieties by more than 7%.

Although the differences in average yield of Rincón Grande compared to the controls were not statistically significant, the yield of Rincón Grande was 6.4% higher than that of N. Comapa and 2.6% higher than that of N. Grijalva, which may be the result of its greater resistance to diseases, such as rust, anthracnose, and common mosaic.

Disease resistance in the greenhouse and the field

In 2019, the reaction of Rincón Grande to rust and anthracnose was evaluated in a greenhouse following the methodology described by Garrido-Ramírez *et al*. (2020). The reaction to rust was assessed on a scale of 1 to 6 based on the type of pustule, while the reaction to anthracnose was assessed on a scale of 0 to 4 that considers the type and size of the lesion. 'Rincón Grande' showed a hypersensitive reaction to rust and an average severity of 2, and a reaction of 1.2 to anthracnose, being resistant to both diseases.

During 2019-2020, its reaction to diseases in the field was determined according to the scale of 1 to 9 described by van Schoonhoven and Pastor-Corrales (1987) and compared with Negro Medellín (N. Medellín), Negro Jamapa (N. Jamapa), and Verdín. In Rincón Grande, Orizaba, Ver., the reaction to web blight [*Thanatephorus cucumeris* (Frank) Donk] was evaluated in autumn-winter (AW) 2019 under residual moisture and the reaction to rust in winter-spring (WS) 2020 under irrigation.

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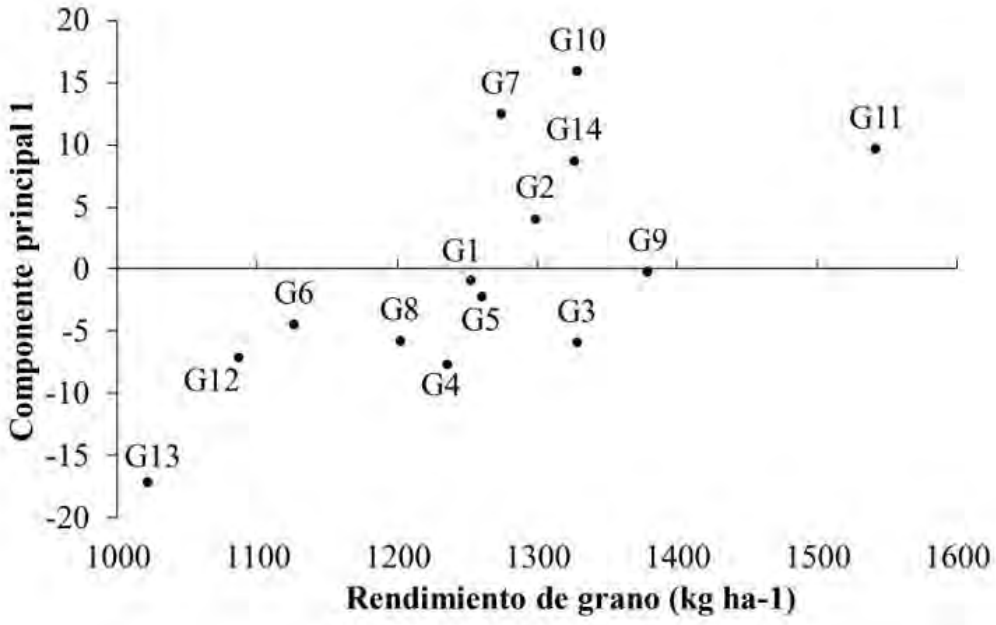
The web blight occurred at the beginning of the stage of pod filling. Rincón Grande was moderately resistant to web blight (3.3) and resistant to rust (2.7). The reaction to BGYMV was evaluated in AW 2019-2020 under residual moisture in three environments in Chiapas, where Rincón Grande showed an intermediate reaction (3.89).

Regional yield trial and validation

During the AW 2019-2020 and WS 2020 cycles, a regional yield trial was conducted in seven environments in Veracruz and Chiapas, in which the yield was determined for Rincón Grande along with 10 lines and the N. Medellín, N. Jamapa, and Verdín varieties. In the combined analysis, the Jamapa Plus/XRAV-187-3-4-4 (G11) line and Rincón Grande (G9) were the most productive with statistically similar yields (LSD, #= 0.05) of 1 542.2 and 1 379.4 kg ha^{-1}.

In the stability analysis with the additive main effects and multiplicative interaction model (Crossa *et al*., 1990), Rincón Grande showed less interaction with the environment with a PC1 close to zero (-0.1531), so it has wide adaptation in the test environments and greater yield stability than the controls (Figure 1).

Figure 1. Yield (kg ha^{-1}) and values of principal component 1 (PC1) for the interaction of 14 black bean genotypes in the regional yield trial, evaluated in seven environments of Veracruz and Chiapas, cycles AW 2019-2020 and WS 2020. G1= Papaloapan/SEN 46-2-6; G2= Papaloapan/SEN 46-3-2; G3= Papaloapan/SEN 46-7-7; G4= Papaloapan/SEN 46-7-10; G5= Papaloapan/SEN 46-7-12; G6= Negro Citlali/XRAV-187-3-1-5; G7= Negro Citlali/XRAV-187-3-1-6; G8= Negro Citlali/XRAV-187-3-1-8; G9= Rincón Grande; G10= Jamapa Plus/XRAV-187-3-4-1; G11= Jamapa Plus/XRAV-187-3-4-4; G12= Negro Medellín; G13= Negro Jamapa; G14= Verdín.



During the 2020 and 2021 AW cycles, Rincón Grande was validated on farmers' land along with the Jamapa Plus/XRAV-187-3-4-4 line and the N. Jamapa variety in central and northern Veracruz. The average yield of Rincón Grande was 1 050 kg ha^{-1}, similar to that of the line and 20.5% higher than that of N. Jamapa, which confirms the higher yield potential of this new variety.

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Technological quality of the grain

The grain of Rincón Grande is opaque black, circular to elliptical in shape in the longitudinal section and medium elliptical in cross-section, with an average weight of 19.3 g per 100 seeds. It has an average testa content of 8.2%, a water absorption capacity of 101% after 18 h of soaking, 26.47% of total proteins, 0.2% of solids in cooking broth, and a cooking time of 89 min, being considered soft for cooking.

Seed availability

At INIFAP, Cotaxtla Experimental Field, Veracruz, original seed is available to produce basic and registered seed in case one wishes to acquire it to produce certified seed.

Conclusions

Rincón Grande is a variety of shrubby beans with short vines, which has high yield potential, is resistant to rust, anthracnose, and common mosaic virus, and tolerant of golden yellow mosaic virus. In addition, it has wide adaptation and yield stability in the tropical and subtropical areas of southeastern Mexico. Its grain, opaque black and small, meets the characteristics of the type of beans demanded by consumers in the southeast and other parts of the country.

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