Description of cultivar

Frailescano: new variety of opaque black bean for Chiapas

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Abstract

In Chiapas, Mexico, bean productivity is affected by the incidence of golden yellow mosaic, the acidity of the soils, and the use of low-yielding landraces that are susceptible to diseases. To help solve this problem in 2013, the Frailescano variety was generated. During 2011 and 2012, the SCN 6 line that gave rise to the Frailescano variety was evaluated in eight environments in Chiapas. The general average yield of the Frailescano variety was 1 150 kg ha^{-1}, similar to that of Negro Papaloapan and significantly higher than that of Negro Comapa. In 2012 its reaction to golden yellow mosaic was evaluated under field conditions. The Frailescano variety showed a 13% incidence, while the Negro Papaloapan and Negro Comapa varieties had an incidence of 40 and 23%, respectively. In that same year, its productive response in acidic soil was evaluated, without and with the application of 1 t ha^{-1} of agricultural lime. In both soil conditions, the Frailescano variety exceeded the yield of the creole Veracruzano by more than 96% and showed a lower yield reduction, due to acid soil stress. From 2014 to 2016, the Frailescano variety was validated in farmers' fields, under irrigation and residual humidity; in both cases, it outperformed the creole Vaina Negra. The general average yield of Frailescano was 1 438 kg ha^{-1}, significantly higher (51.1%) than that of the regional creole. In 2013, Frailescano was registered with the National Seed Inspection and Certification Service for commercial use.

Keywords: *Phaseolus vulgaris* L., adaptability, BGYMV, cultivar, yield.

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The state of Chiapas ranks fifth in bean production at the national level, during 2018, 112 319 ha were planted, of which 64 393 t of grain were produced, mainly of opaque black color, with an average yield of 575 kg ha^{-1} (SIAP, 2020). The low yield is due to the fact that the crop is affected by biotic, abiotic and technical factors, among which are: the incidence of diseases such as the golden yellow mosaic of beans (BGYMV), which can cause significant losses in grain yield, especially when it occurs during the vegetative phase of the crop (López *et al*., 2003; Tosquy *et al*., 2012; Villar *et al*., 2017), the sowing of beans in low fertility and acid soils, which limit development and crop productivity, due to a low availability of nutrients (Zetina *et al*., 2002; López *et al*., 2006) and the use of creole varieties with low yield, limited adaptation and susceptible to BGYMV (Villar *et al*., 2013).

A viable alternative to help solves this problem is to develop improved varieties with high yield potential and with tolerance to the main limiting factors (Rosas *et al*., 2003). The Bean Program of the National Institute for Forestry, Agricultural and Livestock Research (INIFAP) in Chiapas, has developed varieties of black beans with superior agronomic characteristics, some of which are being used by producers (Villar *et al.*, 1993; 2003; 2010; 2011).

In 2013, the registration of the Frailescano variety was obtained in the National Seed Inspection and Certification Service (SNICS), for its commercial use in the tropical areas of the state of Chiapas and regions with similar conditions in southeast Mexico (Villar *et al*., 2013). The objective of this work is to present the origin and process of obtaining this variety, its main agronomic characteristics, its productive behavior in different evaluation environments and the appropriate agroecological conditions for its sowing.

Origin and process of obtaining

This variety originated from the triple cross (NCB 228/RCB 224) F_1//SXB 244, which was made at the International Center for Tropical Agriculture (CIAT), in Cali, Colombia. The development process began in F_1 as a 'gamete' or F_1 plant harvested individually, to create a unique family derived from F_1 and then continued with F_2 in which selection was made under drought conditions in Palmira, Colombia. The F_3 plants were established in Popayan, Colombia, where they were inoculated with *Colletotrichum lindemuthianum* and individual plants resistant to anthracnose caused by this fungus were selected.

F_4 was planted in Santander de Quilichao, Colombia, in acid soil, with low phosphorus content and inoculated with the *Phaeoisariopsis griseola* Ferraris fungus, which causes the angular spot disease. The selections in F_5 were planted in Palmira, to determine the grain yield under drought conditions, from the superior selections an individual plant was taken to obtain a uniform F_6 (Steve Beebe, Com. Pers. Villar *et al*., 2013).

The line from which Frailescano was generated was introduced to Mexico in 2009, along with another 110 lines and to the state of Chiapas in 2010, with the SCN 6 code; through a national performance test of black bean genotypes, to determine their yield, tolerance to diseases and adaptation to acidic soil.

Agronomic characteristics

The plants of the Frailescano variety are of indeterminate growth habit, bushy and erect, type II (Singh, 1982), with medium guides, small leaves and an average plant height of 49.8 cm. Flowering occurs on average at 38 days after sowing, physiological maturity at 70 days and they are ready to be harvested at 80 days after sowing. Its flowers are purple in color, its stems green and its pods are white at physiological maturity and creamy white at harvest, with black, opaque, small-sized and ovoid-shaped grains.

One of the most outstanding characteristics of this variety is its resistance to the bean golden yellow mosaic disease (BGYMV) and its adaptation to the acid soils of the humid tropics of the state of Chiapas (Villar *et al*., 2013). On the other hand, as it is an early cycle variety, its sowing in the summer cycle allows the producer to harvest the beans in the heatwave season, to avoid problems of excess humidity and in the autumn-winter cycle, with residual humidity, escape the occurrence of periods of terminal drought, which commonly occur in the entity (Figure 1) (López *et al*., 2002).

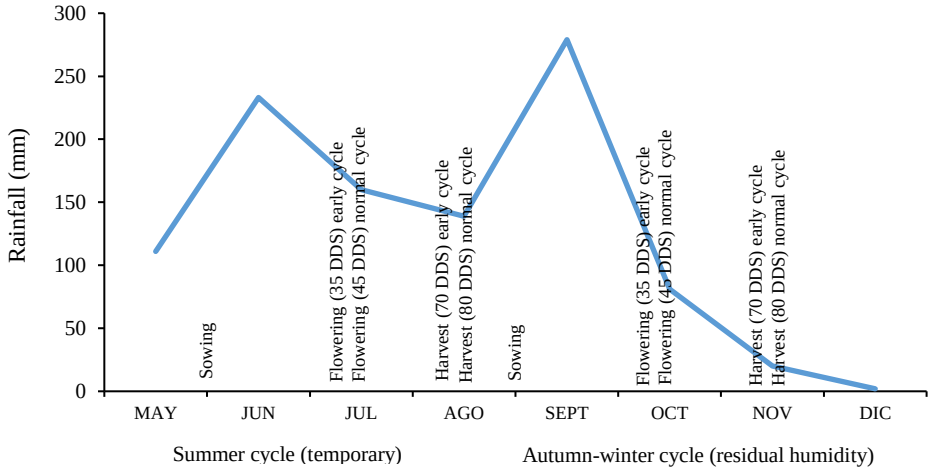

Figure 1. Diagram of bean planting with the Frailescano variety (early cycle) and another commonly used (intermediate cycle), in two cultivation cycles.

Productive behavior

During 2011 and 2012, the Frailescano variety was compared with the commercial varieties Negro Papaloapan and Negro Comapa, used as regional controls, due to its high yield potential and wide adaptation in the tropical areas of Veracruz and Chiapas, through a uniform test of regional yield that was conducted in eight environments of the state of Chiapas, under conditions of rain, residual humidity and irrigation.

Table 1 shows that, in most cases, the Frailescano variety outperformed the two commercial controls. In rainy conditions, the Frailescano variety surpassed the yield of the Negro Papaloapan and Negro Comapa varieties by 17 and 28.4%, respectively. With residual humidity, the percentages of superiority of the Frailescano variety, with respect to these same varieties, were 10.5 and 15.3% and when irrigation was used, 15.8 and 13.2%, respectively. According to the

Student's t test, the general average yield of the Frailescano variety (1 150 kg ha^{-1}) was statistically similar to that of the Negro Papaloapan variety and significantly higher than that of the Negro Comapa variety (Reyes, 1990).

Table 1. Grain yield (kg ha^{-1}) of the Frailescano variety and two commercial varieties of black beans under three humidity conditions in central Chiapas.

Moisture/locality condition	Cycle/year	Frailescano	Negro Papaloapan	Negro Comapa
	Seasonal			
Ocozocoautla-1	Summer 2012	1567	1326	1324
Ocozocoautla-2	Summer 2012	508	312	335
Emiliano Zapata	Summer 2012	813	830	591
Average		963	823	750
Increase with respect to control (%)			17	28.4
	Residual moisture			
Ocozocoautla	A-W 2011	1760	1939	1776
Ocozocoautla-1	A-W 2012	699	558	459
Ocozocoautla-2	A-W 2012	765	317	514
La Union	A-W 2012	1260	1243	1138
Average		1121	1014	972
Increase with respect to control (%)			10.5	15.3
	Irrigation			
Ocozocoautla	W-S 2012	1828	1578	1614
Increase with respect to control (%)			15.8	13.2
General average		1150**	1012.9 ns	968.9
Increase with respect to control (%)			13.5	18.7

V= summer cycle; A-W= autumn-winter cycle; W-S= winter-spring cycle; **= significant difference (t- Student, $p< 0.01$); ns= non-significant mean differences.

These experimental results indicate that, in the center of the state of Chiapas, the Frailescano variety has a similar yield and adaptation potential than the Negro Papaloapan variety and superior to that of Negro Comapa; both varieties were developed by the INIFAP Bean Program for southeastern Mexico (López *et al*., 2007; 2012).

Reaction to BGYMV

In the summer cycle of 2012, under seasonal conditions, in the town of Emiliano Zapata, municipality of Villa Corzo, Chis., the reaction of the Frailescano variety was evaluated, together with the Negro Papaloapan and Negro Comapa varieties, to the incidence bean golden yellow mosaic (BGYMV), at 20, 28 and 35 days after sowing. The Negro Papaloapan and Negro Comapa varieties showed symptoms of the disease from 20 days after sowing, whose incidence percentage

on the last evaluation date was 40 and 23%, respectively, while the Frailescano variety only presented symptoms weak golden yellow mosaic, with an incidence rate of 13%, up to 35 days after sowing (Schoonhoven-Van and Pastor-Corrales, 1987) (Table 2).

Therefore, in cultivation areas with a high incidence of whitefly (*Bemisia tabaci*), a vector of BGYMV, the Frailescano variety is a better sowing alternative than the Negro Papaloapan and Negro Comapa varieties.

Table 2. Percentage of incidence of the golden yellow mosaic in the Frailescano variety and two commercial varieties of beans, in three dates of evaluation of the disease.

Variety	Assessment dates (dds)		
	20	28	35
Frailescano	0	0	13
Negro Papaloapan	12	29	40
Negro Comapa	12	13	23

dds= days after sowing.

Adaptation to acidic soil

In 2012, in the Emiliano Zapata locality, the productive response of the Frailescano variety was compared with the creole Veracruzano, commonly used in central Chiapas (Villar *et al*., 201), in an acid soil (with a pH of 4 and 20% aluminum saturation), without and with the application of 1 t ha^{-1} of agricultural lime. Both under natural conditions of edaphic acidity and with the application of lime, the Frailescano variety exceeded the yield of the creole Veracruzano by more than 96%. The yield reduction, due to acidic soil stress, was lower in the Frailescano variety than in the creole Veracruzano (Table 3). These results indicate that, in the acidic soils of central Chiapas, the Frailescano variety is a better sowing alternative than the creole Veracruzano.

Table 3. Grain yield (kg ha^{-1}) of the Frailescano variety and the creole Veracruzano, in an acid soil, without and with application of agricultural lime, in central Chiapas.

Variety	Soil condition		Reduction (%)
	With 1 t ha^{-1} of lime	Without lime	
Frailescano	1000.5	861.7	13.87
Creole Veracruzano	509.0	428	15.91
Increase with respect to the control (%)	96.6	101.3	

Validation of the Frailescano variety

From 2014 to 2016, the Frailescano variety was validated in farmers' fields, in five environments in the state of Chiapas (two under irrigation conditions and three with residual moisture stored in the soil and the rains that occurred during the crop cycle). In all cases, the creole Vaina Negra commonly used in the entity was used as a control. In the two humidity conditions, the Frailescano variety outperformed the regional creole. It should be noted that, in the town of Alfonso Moguel,

in autumn-winter 2016, there was severe drought during the reproductive phase of the crop, under these restrictive humidity conditions, the Frailescano variety obtained 58% more grain yield than the creole Vaina Negra.

The general average yield of the Frailescano variety was 1 438 kg ha^{-1}, significantly higher (51.1%) than that obtained by the regional creole (Table 4). These results made it possible to confirm at a semi-commercial level and under the soil, humidity and management conditions of the farmers, the greater productive capacity of the Frailescano variety, compared to the creole materials commonly used in the state of Chiapas.

Table 4. Grain yield (t ha^{-1}) of two varieties of beans in validation plots in five environments of Chiapas.

Town/municipality	Cycle and year	Production environment	Frailescano	Vaina Negra	Increment[1] (%)
Jiquipilas, Jiquipilas	AW-2014	Irrigation	2900	1800	61.1
Independencia, Jiquipilas	WS-2014	Irrigation	1600	950	68.4
Espinal de Morelos, Ocozocoautla	AW -2014	HR	850	750	13.3
Alfonso Moguel, Ocozocoautla	AW -2014	HR	1350	950	42.1
Alfonso Moguel, Ocozocoautla	AW -2016	HR	490	310	58.1
Average			1438*	952	51.1

AW= autumn-winter cycle; WS= winter-spring cycle; RH= residual moisture condition; [1]= percentage of increase in yield compared to the control; *= significant difference (t- Student, $p< 0.05$).

Agroecological conditions

The Frailescano variety has adaptation in the tropical areas of the state of Chiapas, as well as in regions with similar environmental conditions in the southeast of Mexico. It can be sown in the summer cycle, under rainstorm and autumn-winter conditions with residual humidity, in areas with altitudes ranging from 0 to 1 200 m, rainfall of at least 350 mm during the crop cycle and average annual temperature between 24 and 26 °C.

It can also be sown in areas that have water and irrigation equipment, where the availability of a sheet of water of around 350 mm is ensured, distributed in six or seven irrigations, with an interval of between 10 and 15 days each during the crop cycle, depending on the humidity conditions in the soil and the ambient temperature (López *et al*., 2002; Ruiz *et al*., 2013).

Seed availability

In the Central Experimental Field of Chiapas, original seed of the Frailescano variety is available, to produce basic and registered seed, in case producer associations or seed companies wish to acquire it, to produce certified seed. The registration number of this variety in the SNICS National Catalog of Plant Varieties, for seed production and commercial use is: FRI-088-060314.

Conclusions

The Frailescano variety showed an average experimental yield of 1 150 kg ha^{-1}, significantly higher than that of the Negro Comapa variety, greater tolerance to golden yellow mosaic, than the Negro Papaloapan and Negro Comapa varieties and better adaptation in conditions of acidic soil and drought. severe, then the regional creoles.

This variety can be cultivated in tropical and subtropical areas of the state of Chiapas and regions with similar conditions in southeastern Mexico, with an altitude of up to 1 200 m, under conditions of rain, residual humidity and irrigation. Its precocity allows the producer to reduce the risk of loss of yield due to the occurrence of periods of terminal drought and its opaque black bean, small in size, meets the characteristics of the type of bean that producers and consumers demand in the state of Chiapas.

Cited literature

López, S. E.; Acosta, G. J. A.; Cumplan, G. J.; Cano, R. O.; Villar, S. B. y Becerra, L. E. N. 2002. Adaptación de genotipos de frijol común en la región tropical húmeda de México. Agric. Téc. Méx. 28(1):35-42.

López, E.; Tosquy, O. H.; Villar, B.; Becerra, E. N. y Ugalde, F. J. 2003. Adaptación, resistencia múltiple a enfermedades y tolerancia a suelos ácidos en genotipos de frijol. Agron. Mesoam. 14(2):151-155.

López, S. E.; Tosquy, V. O. H.; Villar, S. B.; Becerra, L. E. N.; Ugalde, A. F. J. y Cumpián, G. J. 2006. Adaptabilidad de genotipos de frijol resistentes a enfermedades y a suelos ácidos. Rev. Fitotec. Mex. 29(1):33-39.

López, S. E.; Tosquy, V. O. H.; Villar, S. B.; Cumpián, G. J.; Ugalde, A. F. J. y Becerra, L. E. N. 2007. Negro Papaloapan, nuevo cultivar de frijol para las áreas tropicales de México. Agric. Téc. Méx. 33(3):257-267.

López, S. E.; Tosquy, V. O. H.; Jiménez, H. Y.; Salinas, P. R. A.; Villar, S. B. y Acosta, G. J. A. 2012. Rendimiento y adaptación de la variedad de frijol 'Negro Comapa' en dos regiones de México. Rev. Fitotec. Mex. 35(4):309-315.

Reyes, C. P. 1990. Diseño de experimentos aplicados agronomía, biología, química, industrias, ciencias sociales y ciencias de la salud. 3ª (Ed.). Trillas. México, DF. 348 p.

Rosas, J. C.; Hernández, J. C. and Araya, R. 2003. Registration of Bribri´small red bean (race Mesoamerica). Crop Sci. 43(1):430-431.

Ruíz, C. J. A.; Medina, G. G.; González, A. I. J.; Flores, L. H. E.; Ramírez, O. G.; Ortiz, T. C.; Byerly, M. K. F. y Martínez, P. R. A. 2013. Requerimientos agroecológicos de cultivos. INIFAP. CIRPAC. Campo Experimental Centro Altos de Jalisco. Tepatitlán de Morelos, Jalisco, México. Libro técnico núm. 3. 564 p.

Schoonhoven-Van, A. y Pastor-Corrales, M. A. 1987. Sistema estándar para la evaluación de germoplasma de frijol. van Schoonhoven, A. y Pastor-Corrales, M. A. (Comps.). Centro Internacional de Agricultura Tropical (CIAT). Cali, Colombia. 56 p.

SIAP. 2020. Servicio de Información Agroalimentaria y Pesquera. Avance de siembras y cosechas. Resumen por estado. SIAP. Gobierno de México. http://infosiap.siap.gob.mx:8080/agricola_siap_gobmx/ResumenProducto.do.

Singh, S. P. 1982. A key for identification of different growth habits of *Phaseolus vulgaris* L. The XXV Ann. Rep. Bean Improv. Coop. 92-95 pp.

Tosquy, V. O. H.; López, S. E.; Esqueda, E. V. A.; Acosta, G. J. A.; Ugalde, A. F. J. y Villar, S. B. 2012. Rendimiento y reacción a enfermedades de genotipos de frijol en condiciones de temporal y humedad residual. Rev. Mex. Cienc. Agríc. 3(4):727-737.

Villar, S. B. y López, S. E. 1993. Negro INIFAP: nueva variedad de frijol para Chiapas y regiones tropicales similares. Rev. Fitotec. Mex. 16(2):208-209.

Villar, S. B. y López, S. E. 2003. Negro Grijalva. Nueva variedad de frijol para Chiapas y regiones similares. SAGARPA. INIFAP. Campo Experimental Centro de Chiapas. Ocozocoautla, Chis., México. Folleto técnico núm. 2. 22 p.

Villar, S. B.; López, S. E.; Tosquy, V. O. H. y Ugalde, A. F. J. 2010. Rojo INIFAP, nueva variedad de frijol de grano rojo para el trópico de México. Rev. Mex. Cienc. Agríc. 1(5):681-686.

Villar, S. B.; López, S. E.; Tosquy, V. O. H.; Cruz, Ch. F. J. y Acosta, G. J. A. 2013. Frailescano. Nueva variedad de frijol para el estado de Chiapas y regiones bajo condiciones similares. SAGARPA. INIFAP. CIRPAS. Campo Experimental Centro de Chiapas. Ocozocoautla, Chis., México. Folleto técnico núm. 18. 25 p.

Villar, S. B.; Tosquy, V. O. H. y López, S. E. 2017. Rendimiento y adaptación de la variedad de frijol Rojo INIFAP (*Phaseolus vulgaris* L.) en Chiapas, México. Agroproductividad. 10(9):64-70.

Zetina, L. R.; Pastrana, A. L.; Romero, M. J. y Jiménez, Ch. J. A. 2002. Manejo de suelos ácidos para la región tropical húmeda de México. 1ra. (Ed.). INIFAP. CIRGOC. Campos Experimentales del Papaloapan y Huimanguillo. México, DF. Libro técnico núm. 10. 170 p.