Description of cultivar

Salinas: new variety of pinto beans for rainfed areas of Guanajuato

Yanet Jiménez-Hernández[1]
Víctor Montero-Tavera[1]
José Luis Anaya-López[1]
José Cruz Jiménez-Galindo[2]
Guadalupe Herrera-Hernández[1]
Brenda Zulema Guerrero-Aguilar[1]
Jorge Alberto Acosta-Gallegos[1§]

[1]Bajío Experimental Field-INIFAP. Highway Celaya-San Miguel de Allende km 6.5, Celaya, Guanajuato CP. 38110. (jimenez.yanet@inifap.gob.mx; montero.victor@inifap.gob.mx; anaya.jose@inifap.gob.mx; herrera.guadalupe@inifap.gob.mx; guerrero.brenda@inifap.gob .mx). 2v Chihuahua Experimental Range-INIFAP. Av. Hidalgo 1213, Col. Centro, Cd. Cuauhtémoc, Chihuahua (jimenez.cruz@inifap.gob.mx).

[§]Corresponding author: acosta.jorge@inifap.gob.mx.

Abstract

Salinas is a variety of pinto beans, indeterminate-prostrate type III, short-day photoperiod, early maturity, rust-resistant, halo blight and anthracnose, slow darkening grain and high hydration capacity. It was developed by the Bajío Experimental Bean Program (CEBAJ). It was derived from the retro-cross of Pinto Saltillo// (Pinto Saltillo/97-RS-101) and its evaluation started as line F_9 developed by pedigree selection. In later generations, it was evaluated based on yield and resistance to diseases in different places of the Semi-arid Highlands and Central Mexico. In three years of trial (2010-2012) in rainfed environments showed similar performance potential and was superior in disease resistance to Pinto Saltillo. Salinas carries molecular markers of genes associated with rust resistance (Ur3-Ur7, Ur9 and GB), anthracnose (Co1, $Co1^2$, Co2, Co4, $Co4^2$ and Co6) and halo blight (SR13, ST8, SAE15 and SW13) and in the field, shows resistance to the races of these prevalent diseases in Guanajuato. It is also resistant to common mosaic virus (BCMV) due to the presence of the gen I. Salinas gene produces medium-sized grain of mottled pinto type (33 ±3 g 100 $seeds^{-1}$). The average yield in rainfed season depends on the environment and the agronomic management, in the localities of Guanajuato it goes from 622 kg ha^{-1} in San Luis of the Paz, to 3 209 kg ha^{-1}in Salvatierra with optimal fertilization and sowing date.

Keywords: *Phaseolus vulgaris* L., resistance to diseases, slow darkening, undetermined habit-prostrate.

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Pinto beans are the second most widely grown and consumed in the country, only after the Black type, they are widely marketed in the North and in recent years they have expanded with the acceptance of producers and consumers in the Central-West region. The main producing states are Chihuahua, Durango, Zacatecas and San Luis Potosí, and to a lesser extent Querétaro, Guanajuato, Sonora, Coahuila and Aguascalientes (SIAP-SAGARPA, 2016).

Most of the improved varieties and pinto creoles are susceptible to rust (*Uromyces appendiculatus* var. *appendiculatus*) and anthracnose (*Colletotrichum lindemuthianum*), so the incorporation of resistance to these diseases has been one of the objectives of the Bean Improvement Program of the Bajío Experimental Field, the incorporation of resistance is done through the use of diverse sources of germplasm (Beaver *et al*., 2003; Singh and Shwartz, 2010), the direct selection against rust is carried out in temporary environments, the inoculation with breeds of anthracnose of wide distribution in the Plateau of Mexico (Rodríguez-Guerra *et al*., 2006), and recently through the use of molecular markers linked to resistance genes.

Salinas was derived from a backcross between Pinto Saltillo as a recurrent parent and line 97-RS-101 made at the Bajío Experimental Field, Celaya, Guanajuato, in 2002. Pinto Saltillo is a variety of seeds with slow darkening cover developed by selection by Pedigree of a multi-parental cross (Sánchez- Valdéz *et al*., 2004). The line 97-RS-101 is a type II semi-erect growth habit, resistant to rust and seeds with normal darkening cover (Stavely *et al*., 1998). The objective of the cross was to recover lines with resistance to rust and seed cover of slow darkening.

The F_1 plants self-pollinated in the greenhouse in the autumn-winter 2002-2003 and individual selections of F_2 plants were made under rainfed conditions; based on resistance to diseases that occurred naturally. Subsequently, selections were made between and within the segregating families during two growing cycles per year until generation F_9. Selections in the field were based on precocity, disease resistance and pod load, while in the cabinet they were based on seed characteristics such as size, color and cover darkness. The selection process is detailed in Table 1.

Table 1. Selection process for the development of the Salinas variety.

Año	Actividad	Descripción
2002	Crossing	It crosses of parents Pinto Saltillo (feminine) and 97-RS-101 (masculine), and backcrosses of F_1 (masculine) to the progenitor Pinto Saltillo.
2003-2006	Selection of individual plants within segregating populations and families.	Selection in segregating populations and families under irrigation and temporary from generation F_2 to F_8 based on precocity, vigor of the plant, load of pods and resistance to diseases in the field.
2007	Preliminary evaluation of phenotypically uniform lines in generation F_9	Preliminary evaluation of lines under experimental design and comparison with witnesses in local performance test.

Año	Actividad	Descripción
2008-2009	Evaluation of lines in Uniform Test of Adaptation and Performance.	Evaluation under experimental design and comparison with witnesses in various locations in the Plateu. Evaluation of the grain of upper lines under UV light.
2013	Selection of individual plants on the PTB 09016 line.	Selection of individual PTB 09016 plants under temporary in The Bajío, based on rust resistance reaction.
2015-2017	Evaluation of the PTB 09016 line in uniform adaptation and performance test.	Evaluation of PTB 09016M under experimental design and comparison with controls in irrigation and temporal environments in Guanajuato.
2017	Characterization of the new Salinas variety by molecular markers.	Identification of molecular markers associated with slow darkening and resistance genes to common mosaic, rust and anthracnose.
2018	Registration of the Salinas variety.	Registration before SNICS-SAGARPA and multiplication of seed from original to basic in the CEBAJ.

Salinas has a habit of prostrate growth type III and good capacity to cover the soil, which makes it suitable for the marginal seasonal environments prevalent in the Semi-Arid Plateau of North-Central Mexico, including northern Guanajuato and the semiarid Queretaro. The plants produce white flowers, their flowering begins between 39 to 46 days after sowing, and matures between 82 and 92 days.

The number of days to flowering is reduced as planting is delayed at the end of july. Salinas is a short-day reaction to photoperiod, as was found under greenhouse conditions by extending day length with supplementary light, and under field conditions in North Dakota, USA. UU (Osorno, 2017. Com. Pers.). Because they are sensitive to photoperiod, Salinas plants can show phenological plasticity, an adaptive characteristic under temporary conditions (Acosta and White, 1995) and morphological plasticity, so in delayed plantings the plant accelerates its development, modifies the distribution of assimilates and reduces its size. The pods are flat, light green, with four to six seeds, and before reaching physiological maturity they show reddish spots. The color and shape of the seed (Figure 1) and the weight of one hundred seeds (33 ±3 g) are similar to those of Pinto Saltillo, and like this one, the seed coat is of slow darkening.

In the adaptation and yield evaluations (Table 2), irrigation, seasonal and rainy environments with supplementary irrigation and three previously registered varieties were included. In some temporary environments (Ocampo, Guanajuato, in 2012 and 2015 and Jamaica, Dolores, Guanajuato, in 2013), low yields were obtained; while in the other environments that included the Ranch of Peña (Pénjamo, Guanajuato), Ranch The Prado (San Luis of the Paz, Guanajuato), The Calera (Salvatierra, Guanajuato) and the Bajío Experimental Field (Celaya, Guanajuato), they obtained the highest yields. In general, the yield of the varieties was modified according to the environment, mainly due to the presence of diseases and the amount and distribution of precipitation.

Figure 1. Typical grain of the Salinas bean variety. The seed is light cream with brown spots, elliptical in its cross section with an external rhombohedral and semi-kidney shape.

Table 2. Yield and weight of one hundred seeds of four varieties of Pinto beans established in different environments of Guanajuato under irrigation and temporary conditions.

Year and variety	Yield (kg ha^{-1})			Weight of one hundred seeds (g)		
2012	Ocampo[a]	CEBAJ[a]	Peña[b]	Ocampo[a]	CEBAJ[a]	Peña[b]
San Rafael	668	1 649	1 550	34.9	33.3	32.1
Rarámuri	754	2 167	2 025	27.6	33	38.2
P. Saltillo	743	1 752	1 760	29.3	34.4	31.1
Salinas	852	1 852	1 895	28.1	33.7	31.6
2013	CEBAJ[b]	CEBAJ[a]	Jamaica[a]	CEBAJ[b]	CEBAJ[a]	Jamaica[a]
San Rafael	1 681	1 167	851	36.3	43.8	30.8
Rarámuri	2 229	1 400	535	29.5	44	31.5
P. Saltillo	2 107	1 437	1 132	31.6	37.6	29.1
Salinas	2 262	1 278	775	29.9	35.7	28.4
2015	Ocampo[a]	CEBAJ[a]		Ocampo[a]	CEBAJ[a]	
San Rafael	714	2 494		33.2	ND	
Rarámuri	1 335	2 061		36.2	ND	
P. Saltillo	806	1 522		30.2	ND	
Salinas	985	1 499		32.2	ND	
2017	Prado[b]	CEBAJ[c]	Calera[a]	Prado[b]	CEBAJ[c]	Calera[a]
San Rafael	2 502	3 216	2 009	ND	ND	43.4
Rarámuri	2 953	2 996	2 012	ND	ND	40.9
P. Saltillo	2 113	2 001	2 025	ND	ND	35.2

CEBAJ= Bajío Experimental Field, Celaya, Guanajuato; Calera= The Calera, Salvatierra; Jamaica= Jamaica, Dolores Hidalgo; Prado= Ranch The Prado, San Luis of the Paz; Ocampo: Ocampo. Peña= Ranch of Peña, Penjamo. [a]= temporary; [b]= irrigation; [c]= temporary plus supplementary irrigation; ND= not determined.

On average, the San Rafael yield was 1 665 kg ha^{-1}, varying from 668 kg ha^{-1} to 3 216 kg ha^{-1}; that of Raramuri was 1 861 kg ha^{-1}, varying from 535 kg ha^{-1} to 2 996 kg ha^{-1}, that of Pinto Saltillo was 1 581 kg ha^{-1}, varying from 743 kg ha^{-1} to 2 113 kg ha^{-1}, and that of Salinas was 1 728 kg ha^{-1}, varying from 775 kg ha^{-1} to 3 209 kg ha^{-1}. The minimum harvest value was higher in Salinas, while in the maximum value there are no significant differences between Salinas and San Rafael, which demonstrates the high potential of Salinas in different environments.

Salinas grain, produced in 2012 under rainfed and rainfed conditions with supplemental irrigation, was compared with that of Pinto Saltillo and San Rafael for its water absorption capacity and cooking time (characteristics related to grain quality), as well as in the content of iron, zinc and total proteins (related to nutritional quality). The water absorption capacity of the Salinas grain was superior to 100% in both cultivation conditions and similar to that of the other varieties, with the exception of Pinto Saltillo grain produced under storms that was 96.3 ±3.29%, this indicates that the grain of Salinas doubles its weight with hydration and does not present problems of impermeability or hardening, which makes it a suitable variety for the canning industry.

At cooking time, which is considered one of the most important quality parameters of the grain, Salinas had a time of 140 ±4 min under temporary conditions and 139 ±13 min under rainy conditions with an additional irrigation, similar values to those of the other two varieties, which hovered around 139 and 145 min.

In relation to the nutritional quality, the Salinas grain produced in temporary conditions had intermediate content of iron (5.1 ±0.07 mg 100 g^{-1}) and protein (22.3 ±0.08%) in comparison with San Rafael and Pinto Saltillo and the content more low zinc (2.7 ±0.21 mg 100 g^{-1}), similar to that of Pinto Saltillo; while in temporary conditions with supplemental irrigation, the protein content remained similar to that obtained in rainfed conditions (22.8 ±1.19%), but the iron and zinc content increased, although it remained at intermediate values compared to the of the other varieties.

With respect to diseases, in the tests conducted between 2013 and 2017 under rainy conditions in the Bajio Experimental Field, Salinas and Pinto Saltillo behaved similarly showing resistance to common blight and halo blight with damage values between 2 and 3 (on a scale of 1 to 9), except in the year 2015 in which Pinto Saltillo had an intermediate resistance reaction to common blight with a damage value of 4. The Salinas' main advantage is resistance to rust with a value average damage of 2.5 in the three years of evaluation, while Pinto Saltillo had an average of 4.2. Rust is one of the most important diseases because it causes yield losses of 25% to 100% in susceptible varieties (Souza *et al*., 2013), it also has a wide genetic variability of races, of which tens have been identified throughout the world (Jochua *et al*., 2008).

In 2015, the rust severely affected Pinto Saltillo under rainfed conditions in Ocampo, Guanajuato; The Calera, Guanajuato; Zacatecas, Zacatecas and San Juan of Río, Queretaro, with an average damage value of 6.5 compared to the average value of Salinas 3.

Among the molecular markers that were identified in Salinas is SAS13 (Young *et al*., 1998) associated with the $Co4^2$ gene that confers broad resistance to anthracnose; SW13 (Melotto *et al*., 1996) associated with gene *I* that confers resistance to the common mosaic, the Sk14 markers Sk14

(Nemchinova y Stavely, 1998), SA14 (Meine *et al*., 2004), and SI19 (Melotto y Kelly, 1998) associated to the genes Ur-3, Ur-4 and Ur-5, respectively, that confer resistance to rust, and Pvsd1157 (Felicetti *et al*., 2012) associated with slow darkening of the seed coat.

Conclusions

The availability of a new variety of pinto beans with adaptation to rainfed areas in Guanajuato, with high yield potential, greater resistance to rust and capacity for the canning industry, offers an additional option to producers and consumers of beans in Guanajuato the morphological characteristics of the grain, similar to those of Pinto Saltillo, will allow its commercialization and acceptance by bean consumers who already prefer this type of grain.

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