Selection of potato genotypes (*Solanum tuberosum* L.) adapted to the agroecological conditions of the State of Mérida, Venezuela

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Abstract

Potato is considered one of the main agricultural crops in the world in terms of area. In Venezuela occupies the eighth place in production and first place among roots and tubers. The cultivar Granola (German origin) predominates for fresh consumption, but is susceptible to late blight (*Phytophthora infestans*). In this context, the objective of this research was to select genotypes that adaptes to the agroecological conditions of the State of Mérida. The emergence of the genotypes was above 80% in all the localities considered, while the AUDPC values varied from 0 to 7865 in the susceptible control. Seven clones and five cultivars did not present the disease, while the highest values of AUDPC were recorded for the cultivars Granola, Diacol Capiro, Andinita and Montañita, i.e. the materials that showed low resistance to late blight. The highest average yield was registered for the clone 301002.6 (49.63 t.ha^{-1}), while the lowest was obtained for the Unica Peruvian (4.14 t.ha^{-1}). Eighty five percent of the materials outperformed the witness in yield. According to Duncan's multiple test, 23 groups were formed, observing that statistically there are highly significant differences between the genotypes evaluated ($p<0.001$). The dry matter (% solids) was above 14%, however they exceeded 15% of total defects, so only the clones 382121.25, 382151.22 and the cultivars María Bonita, Iniafrit, Fripapa and Diacol Capiro resulted suitable for the industry.

Keywords: processing, characterization, late blight, roots and tubers.

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Introducción

Potato (*Solanum tuberosum* L.) is considered one of the main agricultural crops in the world in terms of area. Together with corn, wheat and rice, it represents the four basic food items of food security and sovereignty (Madroñero et. Al., 2013). It is adapted to a wide range of climates and is found in both tropical and temperate environments and at altitudes from sea level to 4000 meters (Poehlman, 2003). In Venezuela, it occupies the eighth place in production and the first place of roots and tubers (Niño et al., 2004). The main producing states are Mérida, Trujillo, Táchira, Lara, Aragua and Carabobo. Potato production in the country is intended both for fresh consumption and for industry. For the fresh consumption predominates the cultivar Granola of German origin and susceptible to late blight (*Phytophthora infestans*). In addition, other cultivars of Colombian origin are cultivated (Rodríguez et al., 2009), as well as from other countries and to a lesser extent, national cultivars. Farmers demand short-cycle cultivars, with white tubers and with good characteristics for postharvest handling. In this context, the objective of the present work was to select the potato genotypes (*Solanum tuberosum* L.) adapted to the agroecological conditions of the Merida state.

Materials and methods

Promising clones, progeny, commercial and local cultivars were evaluated. The trials were conducted in 11 locations in the state of Mérida, Venezuela for five years (2006-2010). Under an experimental design in completely randomized blocks with 10 treatments and four repetitions. The experiments were analyzed in series of experiments (Gabriel et al., 2017).

The behavior of the genotypes was determined by assessing the emergency response to late blight (*Phytophthora infestans*) commercial performance and frying ability. In addition, a morphological characterization was performed.

Emergency: The emergency was measured 45 days after sowing, counting in each row and estimating the average of the experimental plot.

Response to late blight *(Phytophthora infestans)*

The severity of the disease was evaluated as the percentage of infected leaf area. This variable is recorded throughout the course of the trial along with the date of each reading. The data is collected in each plot or experimental unit (each clone or cultivated within each repetition), can be registered manually or with electronic devices in order to reduce the time and cost of data collection and subsequent analysis (Forbes et al., 2014)

To assess the damage caused by the late blight (*P. infestans*), the area of the affected plant was visually estimated with respect to the total plot, every seven days, from 42 days after sowing. Genotype evaluations were performed by reaction to this disease using the visual scale recommended by Bonierbale et al., (2008), with which the area under the disease progress curve (AUDPC) was calculated.

Yield: To determine yield at harvest, the two central rows of each plot were evaluated and the commercial yield was calculated (t.ha-1). The data were subjected to analysis of variance with the statistical program SAS University. The comparison of means was carried out using the Duncan Test (Gabriel et al., 2017).

Frying ability: The frying tests were carried out by the company PEPSICO ALIMENTOS S.C.A., Planta La Grita, in the state of Táchira, with samples of 10 kg of potatoes for each genotype from the tests. The company assigned the classification of suitable or not suitable for agribusiness considering the characteristics of total defects (sum of undesirable color, % green and internal and

external discoloration of the flakes during the frying process).

Morphological characterization: Morphological variables were evaluated using the descriptors of the International Potato Center (CIP) (Huamán and Gómez, 1994).

Results and Discussion

Emergency

The results showed that genotype emergence was above 80% on average for all locations considered. Only 14 genotypes of the 35 evaluated did not exceed the control, which presented 94.12% (Granola), the highest emergency percentage was for clone 382151.22 (99.5%), while Fripapa INIA had the lowest value 65.94%. These results coincide with those obtained by Meza et al. (2009), who evaluated potato clones in the town of Cuencas, Trujillo state. However, in the work done by Meza et al. (2010) in Marajabú Estado Trujillo emergency values were observed from 40 to 92%, for 16 clones evaluated, these results differ from those obtained in the present investigation probably due to the conditions of development and agronomic management of both trials.

Late blight ocurrence

The AUDPC values varied from 0 to 7865 in the susceptible control. Seven clones and five cultivars did not present the disease (0), while the highest values of AUDPC were for the cultivars Granola (7865), Diacol Capiro (5747.5), Andinita (4232.5) and Montañita (2039.88), so these materials showed low resistance to late blight. Which coincides with the results obtained in evaluations where the indicated cultivars have been used and low resistance to late blight was noted, which indicates that they are genotypes with low resistance and/or tolerance to late blight (González et al., 2011). In this group of genotypes evaluated are those that were generated by the CIP of Population A (vertical resistance) and Population B (horizontal resistance in the absence of R genes) whereby resistance levels are variable. These results are similar in terms of the variability in the response to late blight to those obtained by Rodríguez et al. (2008), which evaluated 190 clones of population B from CIP for resistance to late blight and yield.

Yield

The highest average yield of the localities (Table 1) was recorded in clone 301002.6 (49.63 t.ha-1), while the lowest was obtained in the Peruvian cultivar Unica (4.14 t.ha-1). Eighty five percent of the materials surpassed the witness in performance. However, according to the Duncan means test, 23 groups were formed, observing that statistically there are significant differences between the genotypes evaluated ($p < 0.001$).

The response of clones and potato cultivars in relation to the yield evaluated in TM were different within and between locations, confirming that this component is a varietal characteristic and depends on the genotype-environment interaction (Monar et al., 2015). This trend was observed in research papers where genotypes were evaluated in different locations (Meza et al., 2009; Martínez et al., 2005; Rodríguez et al., 2008).

Table 1. Average yield (t.ha-1) of promising clones, progeny and potato cultivars evaluated in localities of the State of Mérida, Venezuela

Genotypes	Average yield (t.ha^{-1})	Groups
301002.6	49.6	A
391580.30	46.8	AB

391011.17	43,9	ABC
393258.44	42,4	ABCD
393371.159	40,0	BCDE
Andinita	39,8	BCDE
393280.82	39,7	BCDE
392633.54	38,4	BCDEF
382121.25	36.6	CDEFG
393349.68	33.8	DEFGH
386528.7	33.3	DEFGH
392639.1	32.5	EFGHI
393658.44	29.8	FGHIJ
393194.27	29.2	FGHIJ
Achiranax TS-4 (990021)	29.2	FGHIJ
382151.22	29.0	FGHIJ
AchiranaxTPS-67 (96003)	27.4	GHIJK
393085.5	26.6	GHIJK
TPS-25XTPS-67 IP88008)	25.3	HIJKL
MF-IIxTPS-67 (IP88004)	25.2	HIJKL
TPS-25 XTPS-13 (IP88007)	24.7	HIJKLM
393194.1	24.7	HIJKLM
Tibisay	23.1	IJKLMN
393371.58	21.8	JKLMNO
SN Táchira	20.1	JKLMNOP
Maria Bonita	18.3	KLMNOPQ
Montañita	17.7	KLMNOPQ
Cartayita	16.3	LMNOPQ
393280.57	14.9	MNOPQ
Esperanza	13.5	NOPQR
Iniafrit	13.0	NOPQR
Granola (testigo)	11.8	PQR
Carabay	11.4	PQR
Fripapa INIA	10.6	PQR
Diacol Capiro	8.8	QR
Unica Peruana	4.1	R

Frying ability

It was observed in the genotypes evaluated, that dry matter (% solids) is above 14% as required by the processing company, however, when obtaining total defects (sum of undesirable color, % green and internal discoloration and external of the flakes during the frying process) they exceed 15% of total defects in 80% of the samples analyzed, therefore they are not suitable for industrial processing (Table 2), under agronomic handling conditions used in these experiments, as well as the height where the tests were carried out. Postharvest handling also affects processing. Suitable for industry were the following genotypes: Clones 382121.25, 382151.22 and cultivars María Bonita, Iniafrit, Fripapa and as an industrial control: Diacol Capiro. Evaluations of potato cultivars and clones carried out in six locations in the state of Mérida, the Iniafrit, Fripapa INIA and Diacol Capiro cultivars were suitable for industry and the unfit Tibisay cultivar, which coincides with the results obtained in the present investigation (Niño et al, 2004).

Table 2. Average values of the analysis performed on potato samples for industrial processing by Snacks Latin America processing company.

Genotypes	Dry Matter (Ranges)	% of indeseable colour	% of flakes with internal discolouration (rangos)	% of flakes with external discolouration (ranges)	% green	Qualification
Diacol Capiro	15.5	3.76	4.03	6.18	1.22	Apta
Maria Bonita	18.2	0.82	1.8	2.63	0.1	Apta
Fripapa INIA	18.2	2.20	7.14	8.25	3.38	Apta
Iniafrit	17.025	4.24	7.14	6.91	2.53	Apta
382151.22	16.5	4.89	1.8	5.78	3.18	Apta
382121.25	15.2	3.19	2.8	4.12	3.23	Apta
TPS-25 XTPS-13 (IP88007)	15.4	5.9	4.2	1.18	1.7	Apta
301002.6	14.6	100	0	0	0	No apto
386528.7	14	15.62	3.79	11.8	2.90	No apto
391011.17	14.9	100	0	0	0	No apto
391580.30	16.8	95.49	0	0	0	No apto
392633.54	15.3	100	0	0	0	No apto
392639.1	17.7	100	0	0	0	No apto
393085.5	16	53.79	6.93	7.89	2.49	No apto
393194.27	18.2	100	0	0	0	No apto
393194.1	17.9	49.93	15.8	10.03	5.59	No apto
393280.57	13.8	100	0	0	0	No apto
393280.82	15.9	100	0	0	0	No apto
393349.68	19.7	72.03	11.01	0	10.96	No apto
393371.58	16.2	100	0	0	0	No apto
393371.159	15.3	100	0	0	0	No apto
393658.44	18.9	66.42	0	0	3.44	No apto
TPS-25XTPS-67 (IP88008)	16.40	57.56	3.45	3.80	7.18	No apta
MF-IIxTPS-67 (IP88004)	15.70	100	0	0	0	No apta
Achiranax TS-4 (990021)	16.20	88.45	1.18	0	8.94	No apta
Andinita	16.7	100	0	0	0	No apta
Tibisay	11.3	31.45	5.92	4.02	3.26	No apta
Cartayita	15.1	23.33	36.67	21.67	5.67	No apta
Esperanza	15.90	96.40	0.5	0	2.89	No apta
Caribay	15.80	89.53	0	2.19	3.95	No apta
Unica Peruana	15.80	100	0	0	0	No apta
SN Táchira	16,8	100	0	0	0	No apta
Montañita	20.4	45.63	3.82	8.7	6.63	No apta
Granola (control)	18.3	100	0	0	0	No apta

Morphological characterization

The morphological characterization of the materials allows to have the most adequate knowledge of the accessions that are conserved and to be able to use them efficiently (Castillo et al., 2007)

Variability was observed in the 35 genotypes evaluated (Table 3). Tubers were predominated oblong, compressed and round, with white cream skin and white flesh with superficial eyes. The eye depth character is important to consider in breeding programs, where it is always necessary to obtain varieties with superficial eyes (Castillo et al., 2007). These results coincide with those obtained by Meza et al. (2010) when they evaluated the behaviour of clones in Marajabú state Trujillo.

Table 3. Morphological characterization of potato genotypes from the state of Mérida, Venezuela.

Clones, progenies, varieties	Tuber shape	Skin colour	Secondary tuber color	Flesh color	Eyes deepness
301002.6	Compress to round	Pale yellow	np	White	S
382151.22	Obovate	Intense Cream White	np	White	M
382121.25	Flattened	Intense Cream White	np	White	M
386528.7	compressed and oblong	Intermediate white cream	np	White	M
391011.17	ovoid	Pale yellow	np	cream	S
391580.30	round	Pale orange Rugged	np	White	S
392633.54	Flattened Obovate	Cream white	np	cream	S
392639.1	Compressed	Intense Cream White	np	White	P
393085.5	Oblong	Cream white	np	cream	S
393194.27	compressed	Pale cream white	np	White	P
393194.1	compressed	Pale cream white	np	White	P
393280.57	obovate	Intermediate white cream	Marbled pink	Cream	M
393280.82	obovate	white cream	Pink, pigmented and marbled eyes	cream	M
393349.68	Oblong flattened	white cream	with sec color pink in the eyebrows	Yellow	S
393371.58 (Chucmarina)	Oblong	white cream	with pink in eyebrows	Cream	S
393371.159	obovate	white cream	Pink in eyes	white	S
393658.44	compressed	Pale cream white	np	white	P

TPS-25 XTPS-13 (IP88007) Granate INIA	Compressed to round	Pale brown	np	cream	M
TPS-25XTPS-67 (IP88008)	Rounds and oblongs	white cream	np	cream	M
MF-IIxTPS-67 (IP88004)	Rounds	Pale brown	np	cream	M
AchiranaxTPS-67 (96003)	Oblongs	Pale brown	np	cream	M
Achiranax TS-4 (990021)	Oblongs and rounds	Pale brown	np	cream	M
Andinita	oblong	white cream	np	white	S
Tibisay	round	white cream	np	cream	S
Cartayita	Round	Pale brown	np	cream	S
Esperanza	Round	Pale brown	purple red eyebrows, eyes and scattered spots	cream	S
Iniafrit	Elongated oblong	white cream	np	cream	S
Caribay	Rounds	Cream	with a light pink tone	White cream	M
Fripapa INIA	Oblong	Intense pink	np	Yellow	M
Unica Peruana	Oblong	Red	np	cream	S

Continuación... **Tabla 3**

Diacol Capiro	Round slightly flattened	Purple red	np	cream	S
Maria Bonita	oblong	white cream	np	cream	S
SN Táchira	Compressed	Intense Cream White	np	cream	M
Montañita	Oblong	Intermediate white cream	np	White	M
Granola (testigo)	Rounded oval	Pale yellow	np	Pale yellow	S

np= no present, S= superficial, M=medium, P= deep

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Conflicts of interest

The document has no conflict of interest with the institutions where the investigations were conducted.

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