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Evaluation of onion genotypes to slippery skin caused by *Burkholderia gladioli* pv. *alliicola*

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ABSTRACT

Onion's (*Allium cepa*) slippery skin caused by *Burkholderia gladioli* pv. *alliicola* is one of the bacterial diseases that stand out in producing regions of the Brazilian Northeast. Given the importance and potential threat of this disease, and the absence of resistant varieties, the aim of this study was to evaluate the reaction of onion genotypes to slippery skin and to analyze the tolerance stability of the most promising genotypes to different strains of the bacteria. Nine strains of *B. gladioli* pv. *alliicola* were artificially inoculated in onion bulbs cv. Baia Periforme and the three most aggressive strains (CCRMBG39, CCRMBG172 and CCRMBG212) were selected to evaluate the tolerance to the disease. Fifty-eight onion genotypes were challenged with the most aggressive strain (CCRMBG39) and 34 genotypes were considered as tolerant, with a disease severity varying from 9.79 to 13.42 mm. The fifteen most promising genotypes and the most susceptible genotype were selected to study the stability of tolerance using the three selected strains. The genotypes F2 (EHCEB 20151030 x EHCEB 20133015), Cascuda T5, Crioula Mercosul, Juporanga, EHCEB 20111036, Cascuda T6 and EHCEB 20142028 remained tolerant to the disease when inoculated with the three strains, with a disease severity ranging from 9.13 to 14.19 mm. In view of these results, we conclude that these genotypes can be used as potential sources of tolerance to onion slippery skin.

Keywords: *Allium cepa*, genetic resistance, onion bacterial rot.

RESUMO

Avaliação de genótipos de cebola à podridão escorregadia causada por *Burkholderia gladioli* pv. *alliicola*

A podridão escorregadia da cebola (*Allium cepa*) ocasionada pela bactéria *Burkhoderia gladioli* pv. *alliicola* é uma das doenças de origem bacteriana que se destaca nas regiões produtoras do semiárido do Nordeste brasileiro. Tendo em vista a importância da doença, a ausência de variedades resistentes e a potencial ameaça desta enfermidade à cebolicultura, este estudo teve como objetivo avaliar a reação de genótipos de cebola à doença. Nove isolados de *B. gladioli* pv. *alliicola* foram inoculados artificialmente em bulbos de cebola cv. Baia Periforme e os três isolados mais agressivos (CCRMBG39, CCRMBG172 e CCRMBG212) foram selecionados para avaliar a resistência à doença. Cinquenta e oito genótipos de cebola foram avaliados utilizando o isolado mais agressivo (CCRMBG39), sendo 34 genótipos considerados tolerantes, com severidade variando de 9,79 a 13,42 mm. Os 15 genótipos mais promissores e o genótipo mais suscetível foram selecionados para estudar a estabilidade da resistência utilizando-se os três isolados selecionados. Os genótipos F2 (EHCEB 20151030 x EHCEB 20133015), Cascuda T5, Crioula Mercosul, Juporanga, EHCEB 20111036, Cascuda T6 e EHCEB 20142028 mantiveram-se estáveis quanto a tolerância à doença quando inoculados com os três isolados, apresentando severidade variando de 9,13 a 14,19 mm. Diante desses resultados, concluímos que esses genótipos apresentaram-se como potenciais fontes de tolerância à podridão escorregadia da cebola.

Palavras-chave: *Allium cepa*, capa d'água, resistência genética.

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The onion (*Allium cepa*) is cultivated on almost all continents (Kunz *et al.*, 2009), and is the third largest value-added vegetable in the world, together with potatoes and tomatoes (El Balla *et al.*, 2013). In Brazil, the onion has high socioeconomic importance, and stands out as the most produced crop within the genus *Allium*, generating income directly and indirectly (El Balla *et al.*, 2013). According to the latest regional update, in 2017 the Santa Catarina State localized in the South region of Brazil was the main onion producer with 431,759 tons. In turn, Northeastern region of Brazil was responsible for the production of 296,455 tons, and the states of Bahia and Pernambuco stood out with a production of 265,465 tons and 28,152 tons, respectively, which accounted for 99.04% of the regional production (IBGE, 2019).

Several diseases may occur in onion bulbs, standing out slippery skin, which can affect onions from cultivation to the commercialization stage of the bulbs (Romeiro, 2000; Wordell Filho *et al.*, 2006). Slippery skin is caused by the bacteria *Burkholderia gladioli* pv. *alliicola* (Burkholder, 1942), which is present in the main onion production areas of the semi-arid region of Brazilian Northeast (Oliveira *et al.*, 2019). Additionally, the disease is called slippery skin because it occurs in the inner scales or in the centre of the bulb, which soften and produce a sulphurous odour, and the center of the infected bulb can slip out of the top of the onion bulb when squeezed (Silva *et al.*, 2018).

The use of resistant cultivars is the most efficient, economical, and environmentally safe disease control method because it reduces the use of agrochemicals and is compatible with other plant diseases management practices (Camargo, 2011). As such, genetic improvement of the onion has been carried out until the present day, in both red and yellow onions, with the aim of developing cultivars containing high productive potential and resistance to the phytosanitary problems that occur in the region of the São Francisco Valley. Methods have also been developed to improve postharvest conservation, and to produce onions with moderate pungency and good adaptation to the environmental conditions of this region (Souza *et al.*, 2008). However, there are still no onion cultivars that have been proven to be resistant to slippery skin, which could considerably reduce losses caused by this disease (Gava & Tavares, 2016).

Considering the potential threat of this disease, research aimed at selection of sources of tolerance to slippery skin which will greatly contribute to increase productivity of the onion crop in the Northeastern semi-arid region of Brazil. Therefore, this study aimed to evaluate the reaction of onion genotypes to slippery skin caused by *B. gladioli* pv. *alliicola,* and to analyze the tolerance stability of the most promising genotypes to different strains of the bacteria.

MATERIAL AND METHODS

Cultivation of accessions

We evaluated 58 genotypes from the onion germplasm collection maintained at Embrapa Semiárido located in Petrolina-PE, Brazil (Table 1). The genotypes belong to different agronomic types: Baia Periforme, Pêra, Crioula and Grano (Santos *et al.*, 2010).

Seedlings of different genotypes were produced in nurseries in the experimental Station of Embrapa Semiárido using styrofoam trays with 200 cells filled with substrate Bioplant and afterwards, manually transplanted to the field when plants reached 20 cm height, with two to three true leaves, around 35 days after sowing. The management practices for bulb production were those recommended for the crop in that region (Souza *et al.*, 2008), and plants were irrigated by drip irrigation, three times per week. Plants were sprayed with fungicides to control mainly *Alternaria porri* fungus, and with insecticides to control *Thrips* spp. and *Liriomyza* spp.

Strains, cultivation conditions, and preparation of bacterial suspensions

Nine strains of *B. gladioli* pv. *alliicola* (CCRMBG07, CCRMBG38, CCRMBG39, CCRMBG47, CCRMBG89, CCRMBG165, CCRMBG172, CCRMBG175, and CCRMBG212) obtained from the Rosa Mariano Culture Collection of Phytobacteriology Laboratory (LAFIBAC) of the Federal Rural University of Pernambuco, Brazil, were used in the present study. The bacterial strains were obtained from onion bulbs showing slippery skin symptoms in the region of the São Francisco Valley, and were identified by sequencing and phylogenetic analysis of the 16S rRNA region in a previous study (Oliveira *et al.*, 2019). Although several bacteria may cause rotting in onions scales similarly to *B. gladioli* pv. *alliicola* (Silva *et al.*, 2018), we decided to use only this bacterium to evaluate the reaction of onion genotypes because it has been identified as one of the bacterial species that predominate in the region of the São Francisco Valley and has shown high aggressiveness to onion bulbs (Oliveira *et al.*, 2019).

The strains were grown in nutrient yeast dextrose agar (NYDA, 10 g dextrose, 5 g yeast extract, 3 g meat extract, 5 g peptone and 20 g agar, supplemented with up to 1,000 mL distilled water) (Mariano *et al.*, 2016), at 27±2°C for 36-48 h at biochemical oxygen demand (BOD). The bacterial suspensions were prepared in sterile distilled water (SDW) and the concentration was adjusted in a spectrophotometer (Analyzer 500 M, Brazil), for A_{570} = 0.54, which corresponds to 10^8 colony forming units (CFU) mL^{-1}. All the experiments were performed in duplicate.

Analysis of the aggressiveness of *B. gladioli* pv. *alliicola*

Onion bulbs cv. Baia Periforme, characterized as “class 2” (35-50 mm diameter), purchased at the wholesale market [(CEASA (Centro Estadual de Abastecimento) State Supply Center] of Pernambuco, were injured at a depth of approximately 2.5 mm with the aid of an entomological pin. Individually, 10 µL of bacterial suspensions of the strains CCRMBG07, CCRMBG38, CCRMBG39, CCRMBG47, CCRMBG89, CCRMBG165, CCRMBG172, CCRMBG175, and CCRMBG212 were deposited in the wounds. The bulbs were then placed on Petri dishes and maintained in plastic trays containing four sheets of absorbent paper soaked in 20 mL SDW. Trays were covered with transparent plastic bags to create a moist chamber environment and incubated at 27±2°C for 48 h in the BOD. Bulbs treated similarly with SDW were used as the negative control. The experimental design was completely randomized, with four replicates per treatment (bacterial strains), and each repetition consisted of one bulb. We choose to optimize the experimental resources and to standardize all the experiments using only one bulb per repetition due to the low availability of onion bulbs of the genotypes used in the experiments. Disease severity was evaluated by measuring the diameter of the lesion in two opposite directions 48 h after inoculation and computing the mean lesion size. Data were analyzed by analysis of variance (ANOVA), after checking that assumptions were met using the Shapiro-Wilk and Levene’s tests using the Software Statistix (v. 9.0, Tallahassee, Florida, USA). The severity of the lesions caused by the strains were compared using the least significant difference (LSD) test at the

5% probability level using the statistical software mentioned before.

Screening of onion genotypes for tolerance to *B. gladioli* pv. *alliicola*

Fifty-eight genotypes from the onion germplasm collection maintained at Embrapa Semiárido were evaluated (Table 1) in relation to a strain of *B. gladioli* pv. *alliicola*. Onion bulbs characterized as "class 2" were inoculated with the strain CCRMBG39 and incubated as previously described. This strain was selected for inoculation due to the highest disease severity in onion bulbs cv. Baia Periforme, as observed in the aggressiveness study. Bulbs treated similarly with SDW were used as negative control. The experimental design was completely randomized with five replicates, and each repetition consisted of one bulb. The evaluations including computing means of severity assessments, were done by measuring the diameter of the lesion in two opposite directions. Data were analyzed by ANOVA, after checking the assumptions were met using the Shapiro-Wilk and Levene's tests using Software Statistix. The severity of lesions caused by the strain was compared using the Scott-Knott test at the 5% probability level using Sisvar statistical software, v. 5.6 (Ferreira, 2011).

Evaluation of tolerance stability of onion genotypes to *B. gladioli* pv. *alliicola*

Onion bulbs of the genotypes Cascuda T7, EHCEB 20142028, Cascuda T5, EHCEB 20111036, EHCEB 20122003, EHCEB 20141038, Juporanga, Cascuda T6, Alfa SF C-XI, F2 (EHCEB 20151030 x EHCEB 20133015), Crioula Mercosul, EHCEB 201124, EHCEB 201423, IPA 12 and IPA 11, that presented the lowest average lesions and 'Optima PF', that showed to be more susceptible to the disease, all characterized as "class 2", were inoculated with the bacterial strains CCRMBG39, CCRMBG212, and CCRMBG172 and incubated as described before. These strains were chosen due to the highest disease severity in onion bulbs cv. Baia Periforme, observed in the aggressiveness study. Bulbs treated similarly with SDW were used as the negative control. The experiments were carried out in a completely randomized experimental design in a factorial arrangement, represented by three strains and 16 genotypes, with four replications, each consisting of a bulb containing one inoculation point. We evaluated disease severity measuring the diameter of the lesion in two opposite directions and computing the mean lesion size. The severity induced by the strains was submitted to ANOVA, and means were compared using Scott-Knott test at 5% probability level using Sisvar statistical software v. 5.6 (Ferreira, 2011).

RESULTS AND DISCUSSION

Analysis of the aggressiveness of *B. gladioli* pv. *alliicola*

The strains CCRMBG39, CCRMBG212, and CCRMBG172 showed the highest levels of aggressiveness and were not significantly different ($p>0.05$) from each other (Table 2). However, strain CCRMBG172 also did not differ from strains CCRMBG38, CCRMBG175, CCRMBG89, CCRMBG7, and CCRMBG47, which showed moderate levels of aggressiveness. In contrast, strain CCRMBG165 was found to be less aggressive. The difference in severity between the most aggressive strain (CCRMBG39) and the less aggressive one (CCRMBG165) was 4.5 mm. Therefore, strains CCRMBG39, CCRMBG172, and CCRMBG212 were selected to be used in the following experiments, in the present study. Similarly, Oliveira *et al*. (2019) also observed the existence of different levels of disease severity caused by different strains of *B. gladioli* pv. *alliicola*.

Several bacteria such as some *B. cepacia* complex (BCC) species, *Pseudomonas aeruginosa* (Wordell Filho *et al*., 2006), and *Serratia marcescens* (Malavolta Júnior *et al*., 2008) may cause rotting in onions scales similarly to *B. gladioli* pv. *alliicola* (Silva *et al*., 2018; Oliveira *et al*., 2019). However, according to Oliveira *et al.* (2019), *B. gladioli* pv. *alliicola* seems to predominate in the region of the São Francisco Valley. In addition, based on pathological characterization of strains of these bacteria, the authors found that strains of BCC and *B. gladioli* pv. *alliicola* resulted in higher values of severity, disease index, and area under the disease progress curve and had a shorter incubation period than *P. aeruginosa* strains. Nevertheless, so that tolerant genotypes may be used successfully in breeding programs or for the management of the rotting caused by these bacteria is also essential to evaluate the tolerance of the onion genotypes to species present in the BCC.

In the present study, only the severity of slippery skin (measured as lesion size) was used to evaluate the reaction of the onion genotypes. This variable was selected because of the high aggressiveness and the low incubation period of this pathogen, which varies from 7 to 16 h (Oliveira *et al*., 2019), which demonstrates that the pathogen colonizes and begins maceration of the bulb tissues very quickly. In addition, Silva (2016) observed positive correlations between severity and area below the disease progression curve, as well as negative correlations between these variables and the incubation period, indicating that any of these variables can be used in the research on slippery skin.

Screening of onion genotypes to *B. gladioli* pv. *alliicola*

No significant differences were observed ($p>0.05$) for the variances of the replicates of the experiments, and thus the data were evaluated as repetitions over time. Significantly different levels of tolerance to slippery skin ($p\leq0.05$) were observed among the 58 genotypes, 48 h after inoculation (Table 1). The genotypes were clustered in three groups of severity, a, b, and c, which were classified in this study as tolerant, moderately tolerant, and susceptible, respectively. Thirty-four genotypes were considered tolerant, with severity ranging from 9.79 to 13.42 mm; 21 genotypes were considered moderately tolerant, with severity ranging from 13.89 to 16.88 mm; and three genotypes were considered susceptible, with severity ranging from 18.39 to 19.86 mm. None of the 58 genotypes tested showed immunity (absence of disease) to strain CCRMBG39 (Table 1).

Pereira *et al*. (2016) analyzed the resistance of 64 onion genotypes to purple blotch (*Alternaria porri*), and were able to classify the evaluated genotypes in four distinct groups (resistant, moderately resistant, susceptible, and highly susceptible), with proportions of 16.41%, 47.76%, 26.86%, and 4.47%, respectively. The genotypes Crioula Mercosul, Bola Precoce, Juporanga L2, Juporanga L7, and Roxa do Barreiro were considered resistant to purple blotch by these authors and were also classified as tolerant to strain CCRMBG39 of *B. gladioli* pv. *alliicola* in the present study.

Souza *et al*. (2008) evaluated the productive performance of onion genotypes in the Northeastern semi-arid region of Brazil and demonstrated that the 'Régia' genotype was one of the most promising in the region of the São Francisco Valley. In addition, when evaluating onion genotypes to purple blotch, Pereira *et al*. (2016) verified that this genotype showed moderate tolerance to this disease. However, in the present study, the 'Régia' genotype was found to be susceptible to *B. gladioli* pv. *alliicola*.

Evaluation of tolerance stability of onion genotypes to *B. gladioli* pv. *alliicola*

Among the 34 genotypes considered to be tolerant in the present study, 15 genotypes that presented the lowest average lesions [Cascuda T7, EHCEB 20142028, Cascuda T5, EHCEB 20111036, EHCEB 20122003, EHCEB 20141038, Juporanga, Cascuda T6, Alfa SF C-XI, F2 (EHCEB 20151030 x EHCEB 20133015), Crioula Mercosul, EHCEB 201124, EHCEB 201423, IPA 12 and IPA 11] and the most susceptible genotype (Optima PF) were studied for tolerance stability.

No significant differences were observed (p>0.05) for the variances of the replicates of the experiments, and thus the data were evaluated as repetitions over time. No significant interactions were observed between genotypes and strains at 5% probability. Therefore, data regarding the genotypes

Table 1. Evaluation of onion genotypes of different agronomic types (AT) to slippery skin by inoculation with *Burkholderia gladioli* pv. *alliicola* strain CCRMBG39. Petrolina, Embrapa Semiárido, 2016.

Genotype[1]	AT[2]	Severity[3]	Tolerance class[4]
Alfa SF 'A'	Ba	14.30 b[5]	MT
Alfa SF 'B'	Ba	16.88 b	MT
Alfa SF C-XI	Ba	11.42 a	T
Alvorada	NI	15.15 b	MT
Bola Precoce	Ba	13.10 a	T
BRS 367	NI	13.22 a	T
Cascuda T5	NI	10.54 a	T
Cascuda T6	NI	11.14 a	T
Cascuda T7	NI	9.79 a	T
Cascuda T8	NI	12.60 a	T
Conquista	Ba	12.71 a	T
Crioula Mercosul	Cr	11.51 a	T
EHCEB 20101003	NI	15.68 b	MT
EHCEB 20101017	NI	12.39 a	T
EHCEB 20101019	NI	13.11 a	T
EHCEB 20102017	NI	12.64 a	T
EHCEB 20102019	NI	14.24 b	MT
EHCEB 20111006	NI	16.27 b	MT
EHCEB 20111036	NI	10.63 a	T
EHCEB 20112006	NI	14.53 b	MT
EHCEB 20112036	NI	12.16 a	T
EHCEB 201124	NI	11.52 a	T
EHCEB 20122003	NI	10.95 a	T
EHCEB 20141008	NI	15.95 b	MT
EHCEB 20141027	NI	13.00 a	T
EHCEB 20141028	NI	13.37 a	T
EHCEB 20141038	NI	10.98 a	T
EHCEB 20141040	NI	15.49 b	MT
EHCEB 20142	NI	12.29 a	T
EHCEB 20142008	NI	19.86 c	S
EHCEB 20142027	NI	14.96 b	MT
EHCEB 20142028	NI	10.08 a	T
EHCEB 20142038	NI	12.89 a	T
EHCEB 20142040	NI	15.60 b	MT
EHCEB 201423	NI	11.69 a	T
EHCEB 201426	NI	15.58 b	MT
EHCEB 201427	NI	13.19 a	T
EHCEB 20146	NI	14.51 b	MT
EHCEB 201513	NI	12.88 a	T
EHCEB 201515	NI	15.67 b	MT

Table 1. continuation

Genotype[1]	AT[2]	Severity[3]	Tolerance class[4]
Express	NI	14.33 b	MT
F2 (EHCEB 20131006 x EHCEB 20133014)	NI	12.42 a	T
F2 (EHCEB 20151030 x EHCEB 20133015)	NI	11.44 a	T
Imperatriz	NI	12.71 a	T
IPA 10	NI	13.89 b	MT
IPA 11	Ba	11.76 a	T
IPA 12	Ba	11.74 a	T
Juporanga	Ba	11.00 a	T
Luminosa do Enza	NI	12.26 a	T
Optima F1	NI	14.79 b	MT
Optima Pf	Gl	18.39 c	S
Primavera	Ba	14.48 b	MT
Rainha	NI	13.42 a	T
Regia	Gl	18.91 c	S
Roxa do Barreiro	NI	12.37 a	T
São Paulo	Gr	14.48 b	MT
Serrana	Ba	16.62 b	MT
Sirius F1	NI	14.70 b	MT
CV (%) = 26.13[6]			

[1]Genotypes from the onion germplasm bank of Embrapa Semiárido, Petrolina-PE, Brazil. [2]AT = agronomic types; NI = no information available; Ba = Baia periforme; Cr = Crioula; Gl = Gladalan; Gr = Grano; [3]Disease severity estimated by measuring the diameter of the lesion. [4]Tolerance class: T = tolerant, MT = moderately tolerant, and S = susceptible; determined according to severity groups observed in this study. [5]Mean of five replicates. Mean scores in the column followed by the same letter do not differ significantly (p>0.05) from each other by Scott-Knott test. [6]Variation coefficient.

Table 2. Disease severity caused by nine strains of *Burkholderia gladioli* pv. *alliicola* artificially inoculated in onion bulbs, cv. Baia Periforme class 2 (35-50 mm diameter). Recife, UFRPE, 2016.

***Burkholderia gladioli* pv. *alliicola* strain**	Severity[1]
CCRMBG7	11.94 bc[2]
CCRMBG38	13.29 bc
CCRMBG39	16.01 a
CCRMBG47	11.88 bc
CCRMBG89	12.94 bc
CCRMBG165	11.50 c
CCRMBG172	13.89 ab
CCRMBG175	12.95 bc
CCRMBG212	15.59 a
CV (%) = 20.13[3]	

[1]Severity estimated by measuring the diameter of the lesion. [2]Mean of four replicates. Mean values in the column followed by the same letter did not differ significantly (p>0.05) from each other by the LSD test. [3]Variation coefficient.

were analyzed separately for each strain. The absence of significant interactions between genotypes and strains could be assigned to the uniformity of reaction of the genotypes in relation to the strains of *B. gladioli* pv. *alliicola*. In turn, this must be regarded as a good signal because indicate that genotypes could be equally tolerant to the strains of this bacterium.

Regarding the reaction to the CCRMBG39 strain, all genotypes were found to be tolerant and were significantly different ($p \leq 0.05$) from Optima PF, which was susceptible (Table 3). This result was expected and confirmed the reaction of these genotypes to strain CCRMBG39, which was observed in the experiment for screening onion genotypes. According to the reaction of onions to the strain CCRMBG172, the genotypes Cascuda T5, Cascuda T6, Cascuda T7, Crioula Mercosul, EHCEB 20111036, EHCEB 20122003, EHCEB 20142018, F2 (EHCEB 20151030 x EHCEB 20133015), IPA 11 and Juporanga behaved as tolerant, while the other genotypes were considered as susceptible. In turn, when the strain CCRMBG212 was inoculated, we verified that the genotypes Cascuda T5, Cascuda T6, Crioula Mercosul, EHCEB 20111036, EHCEB 20141038, EHCEB 20142028, EHCEB 201423, F2 (EHCEB 20151030 X EHCEB 20133015), IPA 12, and Juporanga were tolerant, while the other genotypes were susceptible. Unfortunately, there are no studies about the genetic diversity of strains of *B. gladioli* pv. *alliicola* that may help explain the reasons for these variations. However, such variations are likely due to genetic variations between the strains, which may reflect in the different aggressiveness levels observed. The genotype Optima PF showed to be susceptible while the genotypes F2 (EHCEB 20151030 x EHCEB 20133015), Cascuda T5, Crioula Mercosul, Juporanga, EHCEB 20111036, Cascuda T6, and EHCEB 20142028 remained stable about their tolerance to slippery skin considering the three strains of *B. gladioli* pv. *alliicola* tested (CCRMBG39, CCRMBG212, and CCRMBG172). Therefore, we concluded these genotypes were found

Table 3. Reaction of 16 onion genotypes to slippery skin when artificially inoculated with strains CCRMBG39, CCRMBG172, and CCRMBG212 of *Burkholderia gladioli* pv. *alliicola*. Petrolina, Embrapa Semiárido, 2016.

Onion genotype	Severity[1]		
	CCRMBG39	CCRMBG172	CCRMBG212
Alfa SF C-XI	12.50 a[2]	14.54 b	15.10 b
Cascuda T5	11.57 a	9.94 a	11.53 a
Cascuda T6	10.39 a	10.23 a	13.01 a
Cascuda T7	9.99 a	10.46 a	13.86 b
Crioula Mercosul	10.41 a	9.13 a	12.08 a
EHCEB 20111036	14.19 a	11.64 a	12.95 a
EHCEB 201124	12.02 a	13.21 b	15.99 b
EHCEB 20122003	13.34 a	11.47 a	14.37 b
EHCEB 20141038	11.65 a	12.91 b	12.19 a
EHCEB 20142028	10.75 a	10.64 a	13.14 a
EHCEB 201423	10.30 a	12.40 b	11.84 a
Optima PF	20.30 b	21.57 b	16.67 b
F2 (EHCEB 20151030 x EHCEB 20133015)	10.88 a	10.31 a	10.40 a
IPA 11	13.87 a	11.20 a	15.32 b
IPA 12	11.13 a	14.23 b	12.25 a
Juporanga	12.25 a	10.05 a	12.52 a
CV (%)[3]	17.57	16.01	18.07

[1]Disease severity estimated by measuring the diameter of the lesion on onion bulbs caused upon inoculation of three strains of *Burkholderia gladioli* pv. *alliicola*. [2]Mean of four replicates. Mean scores in the column followed by the same letter do not differ significantly (p>0.05) from each other by the Scott-Knott test. [3]Variation coefficient.

to be promising sources of tolerance to slippery skin and could be better explored in breeding programs.

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