SURVIVAL OF PASSION FRUIT SPECIES WITH OR WITHOUT PARTIAL ROOT EXPOSURE ON AN AREA WITH HISTORY DISEASE OF *Fusarium solani*

AGROECOSSISTEMAS
Núcleo de Meio Ambiente
Universidade Federal do Pará
Rua Augusto Corrêa, 01, Guamá
Belém, Pará, Brasil
https://periodicos.ufpa.br/index.php/agroecossistemas

Jonilson Santos de Carvalho
Universidade Estadual do Sudoeste da Bahia
jonilsonif@gmail.com

Abel Rebouças São José
Universidade Estadual do Sudoeste da Bahia
abeljose3@gmail.com

Alessandro de Magalhães Arantes
Instituto Federal de Educação, Ciência e Tecnologia Baiano
arantes2005@yahoo.com.br

Alcebíades Rebouças São José
Universidade Estadual do Sudoeste da Bahia
alreboucas@gmail.com

Maira de Araújo Kurfis
Instituto Federal de Educação, Ciência e Tecnologia Baiano
maira_kurfis@hotmail.com

ABSTRACT: Growing passion fruit stands out as an important economic activity in several regions of Brazil, especially in the Northeast, which accounts for more than 60% of the national production. Nevertheless, passion fruit production systems lack technologies, which is one of the reasons for increased disease incidence and low fruit yields. Root and collar rot caused by *Fusarium solani* (Mart.) Sacc.. is a highly important passion fruit disease in Brazil mainly because it causes the death of infected plants and has no available control methods. Therefore, this work aimed to evaluate the survival of three species of passion fruit: *Passiflora edulis* Sims, *Passiflora cincinnata* Mast and *Passiflora foetida* L., under planting systems with and without partial exposure of the roots, evaluated over ten periods. The treatments were arranged in a 3x2x10 factorial laid out in randomized block design. The incidence of *F. solani* was evaluated on a weekly basis by the number of dead plants. The experiment was carried out from January to June 2019, in an area of 0.3 ha, with a history of *F. solani* incidence, located at the Instituto Federal Baiano *campus* Guanambi. Results show that partial exposure of the root system reduces the percentage of dead plants by *F. solani*, and *P. foetida* stands out as highly resistant to *F. solani*. Thus, using integrated management strategies is a viable alternative for growers to mitigate the damage caused by passion fruit root and collar rot.

KEYWORDS: Biocontrol, Phytosanitary, *Passiflora*.

Received: 2019-10-04
Evaluated: 2020-09-10
Accepted: 2021-02-10

SOBREVIVÊNCIA DE ESPÉCIES DE MARACUJAZEIRO COM OU SEM EXPOSIÇÃO PARCIAL DAS RAÍZES, EM ÁREA COM HISTÓRICO DE *Fusarium solani*

RESUMO: A passicultura destaca-se como uma importante atividade econômica em várias regiões do Brasil, sobretudo no Nordeste, que detém mais de 60% da produção nacional. Ainda assim, o sistema de produção da cultura do maracujá é carente em tecnologias, sendo este um dos motivos do aumento da incidência de doenças e baixa produtividade da cultura. Entre as doenças importantes para o maracujazeiro no Brasil, destaca-se a podridão do colo e raiz, causada pelo *Fusarium solani* (Mart.) Sacc., principalmente por causar a morte das plantas infectadas e ainda não existir um manejo curativo. Portanto, o objetivo deste trabalho foi avaliar a sobrevivência de três espécies de maracujazeiro: *Passiflora edulis* Sims, *Passiflora cincinnata* Mast e *Passiflora foetida* L., submetidas ao sistema de plantio com e sem exposição parcial das raízes, avaliadas em dez períodos, em esquema fatorial 3x2x10, em blocos casualizados. A incidência de *F. solani* foi realizada por meio de levantamento semanal do número de plantas mortas. O experimento foi conduzido no período de janeiro a junho de 2019, em uma área de 0,3 ha com histórico de *F. solani*, localizada no Instituto Federal Baiano campus Guanambi. Verificou-se que a exposição parcial do sistema radicular reduz o percentual de plantas mortas por *F. solani*, e, dentre as espécies avaliadas, destaca-se o *P. foetida* como altamente resistente ao *F. solani*. Portanto, o uso de estratégias de manejo integradas é uma alternativa viável aos passicultores para mitigar os danos causados pela podridão do colo e raiz.

PALAVRAS-CHAVE: Biocontrole, Fitossanidade, *Passiflora*.

SUPERVIVENCIA DE GENOTIPOS DE MARACUYÁ CON Y SIN EXPOSICIÓN PARCIAL DE RAÍCES EN UN ÁREA CON ANTECEDENTES DE *Fusarium solani*

RESUMEN: La producción de maracuyá se destaca como una actividad económica importante en varias regiones de Brasil, especialmente en el Noreste, que representa más del 60% de la producción nacional. Aun así, el sistema de producción de cultivos de maracuyá carece de tecnologías, que es una de las razones de la mayor incidencia de enfermedades y la baja productividad del cultivo. Entre las enfermedades importantes para la fruta de la pasión en Brasil, se destaca la podredumbre del cuello y raíces, causada por *Fusarium solani* (Mart.) Sacc., principalmente porque causa la muerte de plantas infectadas y no hay un tratamiento curativo. El objetivo de este trabajo fue evaluar la supervivencia de tres especies de maracuyá: *Passiflora edulis* Sims, *Passiflora cincinnata* Mast e *Passiflora foetida* L., sometidas al sistema de plantación con y sin exposición parcial a la raíz, evaluado durante diez períodos, en un esquema factorial 3x2x10, en bloques al azar. La incidencia de *F. solani* se realizó mediante una evaluación semanal del número de plantas muertas. El experimento se realizó de enero a junio de 2019, en un área de 0.3 ha con historia de *F. solani*, ubicado en el Instituto Federal Baiano *campus* Guanambi. La exposición parcial del sistema radicular redujo el porcentaje de plantas muertas por *F. solani*, y entre las especies evaluadas, *P. foetida* se destaca como altamente resistente a *F. solani*. Por tanto, el uso de estrategias de manejo integradas es una alternativa viable para que los agricultores mitiguen el daño causado por la podredumbre del cuello y raíces

PALABRAS CLAVE: Biocontrole, Sanidade vegetal, *Passiflora*.

INTRODUCTION

Yellow passion fruit (*Passiflora edulis* Sims) stands out from the cultivated passion flower species and accounts for more than 90% of passion fruit orchards in Brazil (MELETTI, 2011; JESUS et al., 2017). This popularity is due to a set of characteristics, including greater vigor and productivity of plants, and higher acidity and better juice yield of fruits (FERREIRA et al., 2016). However, this species faces several phytosanitary problems, to the point of shortening passion fruit cultivation from perennial to annual, which is unfeasible in some regions (KUDO et al., 2012).

Of diseases reducing the yield potential of passion fruit, we highlight the root and collar rot, caused by the fungus *Fusarium solani* (FISCHER et al., 2005a; BUENO et al., 2010). The lack of effective measures to manage this disease reduces the longevity of the orchard, decreases fruit productivity and increases production costs; as a result, the orchard is often abandoned (SÃO JOSÉ et al., 2011).

Given the risk of reducing passion fruit production, several strategies have been tested to increase the feasibility of growing the crop, including the use of resistant genetic material (CAVICHIOLI et al., 2011; PREISIGKE et al., 2017) and biofungicides (BOMFIM et al., 2010;

SILVA et al., 2014). Furthermore, strategies such as planting with partial exposure of the root system, an empirical technique employed by some passion fruit growers to mitigate the damage caused by some soil fungi, need scientific proof.

Of promising strategies, the use of resistant genetic material is an efficient strategy in the management of soil-borne diseases; however, commercial passion fruit cultivars resistant to root and collar rot have not been developed yet (SANTOS FILHO et al., 2017). Evaluating and selecting disease-resistant species to serve as rootstock may also represent a viable alternative (SILVA et al., 2017).

Passiflora cincinnata is a potential rootstock, given that it has moderate tolerance to soil-borne pathogenic fungi compared to *P. edulis*; another species is *P. foetida*, which is a genetic material still little exploited, but with the potential to be used as a rootstock and in breeding programs (PREISIGKE et al., 2017).

Another option to fight the disease is to interfere in the environment where the pathogen develops optimally (MARCHIONATTO, 1949). Based on the experience of some passion fruit growers, who have used partial exposure of the root system as a management method against *F. solani*, it is inferred that this can be a useful practice, based on the principle of regulation.

Thus, it is relevant to evaluate whether the management of the planting system, with or without partial exposure of the roots, is a viable alternative for reducing plant mortality in areas with a history of *F. solani*. The objective was to evaluate the survival of three passion fruit species (*P. edulis*, *P. cincinnata* and *P. foetida*) under planting system with or without partial exposure of the root system, on an area with a history of *F. solani*.

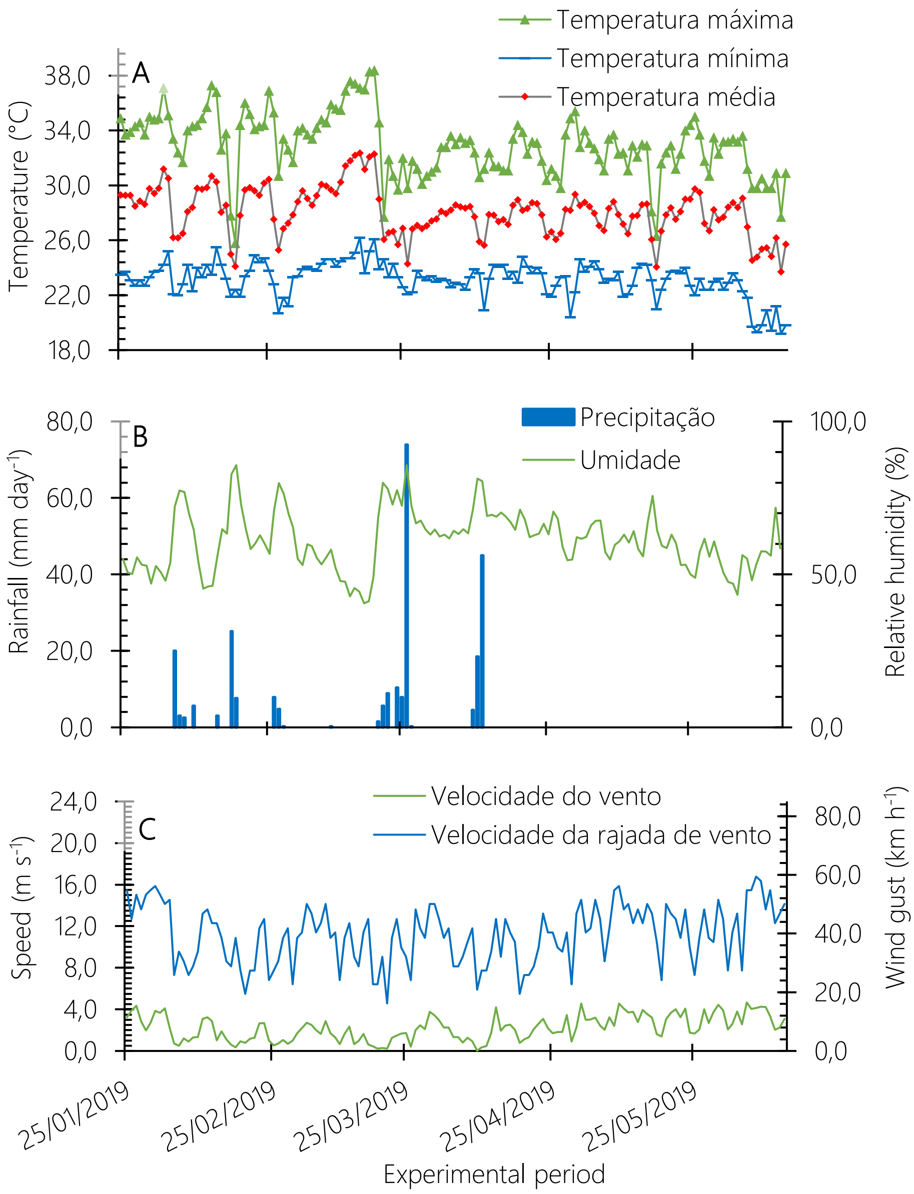
MATERIAL AND METHODS

EXPERIMENTAL CONDITIONS

The experiment was carried out from January to June 2019, on an area of 0.3 ha located at the Instituto Federal Baiano campus Guanambi, Bahia state, Brazil (latitude 14º17'27'' S, longitude 42º46'53'' W, and altitude 537 m). The soil is a typical medium-textured dystrophic Red-Yellow latosol, weak A horizon, hypoxerophilic caatinga phase.

Maximum and minimum temperatures, rainfall, relative humidity and average wind speed and wind gusts were collected using an automatic weather station (Vantage Pro Integrated Sensor Model, manufactured by Davis Instruments, Wayward, California, USA) installed near experiment. Weather data revealed maximum temperatures close to 40 °C, some rain events in February, March and April, moderate to strong winds with gusts of up to 60 km h^{-1} (Figure 1). Soil information was obtained from 15 soil samples collected throughout the experimental area, at depths of 0-20 cm, to form a composite sample, which were later sent to the Soil Laboratory of the State University of Southwest da Bahia – UESB, campus Vitória da Conquista, for testing (Table 1).

Figure 1. Maximum, minimum and mean temperature (°C) (A); rainfall (mm) and relative humidity (%) (B); mean wind speed (m s^{-1}) and wind gusts (km h^{-1}) (C), recorded using a weather station located at IF Baiano, *campus* Guanambi, from January to June 2019



Source: Created by the authors.

Table 1. Soil test results for the experimental area. Guanambi – BA, 2018.

Property	Unit	Depth 0 - 20 cm
pH (H_2O)	--	7.50
P	mg dm^{-3}	49.00
K^+	$cmol_c$ dm^{-3}	0.36
Ca^{2+}	$cmol_c$ dm^{-3}	3.20
Mg^{2+}	$cmol_c$ dm^{-3}	2.30
Al^{3+}	$cmol_c$ dm^{-3}	0.00
H^+	$cmol_c$ dm^{-3}	0.90
Na^+	$cmol_c$ dm^{-3}	0.13
S.B[1]	$cmol_c$ dm^{-3}	6.00
t[2]	$cmol_c$ dm^{-3}	6.00
T[3]	$cmol_c$ dm^{-3}	6.90
V[4]	%	87.00
m[5]	%	0.00
ESP[6]	%	2.00
O.M.[7]	g dm^{-3}	7.00
Textural class		Sandy loam

[1]sum of bases; [2]effective cation exchange capacity, effective CEC; [3]CEC a pH 7.0; [4]base saturation; [5]aluminum saturation; [6]exchangeable sodium percentage; [7]soil organic matter. SOURCE: Soil laboratory of UESB, 2017.

EXPERIMENT

Plants were drip irrigated with an 8 L h^{-1} dripper per plant. Irrigation scheduling was based on the reference evapotranspiration (ETo) determined by the Penman-Monteith method using weather data collected daily. Crop coefficients for the calculation of crop evapotranspiration were as a function of plants' phenological phases.

Napier grass (*Pennisetum purpureum* Schum.) was planted around the experimental area to serve as windbreaks, particularly on the sides where the winds predominated. Cropping practices were performed according to technical recommendations for passion fruit. Fertilization was carried out based on soil test results and fertilizer recommendations for the crop (BORGES and SOUZA, 2010).

At 15 days after transplanting, all lateral shoots were removed, leaving only the main stem, which was trained as a single stem using a cotton string tied to a small stake fixed to the ground up to a wire of a trellis. Afterwards, as soon as the plants reached 1.8 m tall, they were trained along the wire. The lateral branches grew downwards, forming a curtain, and pruned 20 cm above the ground (FIGUEIREDO et al., 2015).

Weeds were periodically mowed between rows of plants using a mower coupled to a tractor's power take-off, and, within the rows, using a costal mower. Clippings resulted from mowing was added to the rows of plants as mulching, which prevented new weeds to come out, as controlling weeds using a hoe should be avoided on areas infested by *F. solani*. Pests were controlled according to the recommendations available in the AGROFIT database (MAPA, 2018).

TREATMENTS AND EXPERIMENTAL DESIGN

Treatments were laid out in randomized blocks, arranged in a 3x2x10 factorial: three passion fruit species (*P. edulis* and *P. cincinnata*, obtained from the selection of seeds from Guanambi region, and *P. foetida*, from Mossoró – RN) under either conventional planting system (no exposure of roots) or with partially exposed roots, and evaluated in ten seasons. Plants were grown on an area naturally infested with *F. solani*. The treatments were replicated three times and each plots had seven observation plants, which were evaluated every seven days.

Partially exposing the root system was achieved by raising the planting holes to 15 cm from the ground level. 60 days after transplanting (DAT), jets of water were used to remove dirt from the base of the plant, to expose the first six centimeters of the root system (Figure 2).

Figure 2. Raised planting holes at 15 cm from the ground surface (A e B); water jet used to expose partially the root system (C); exposed root system (D). Guanambi – BA, 2019.

Source: Created by the authors.

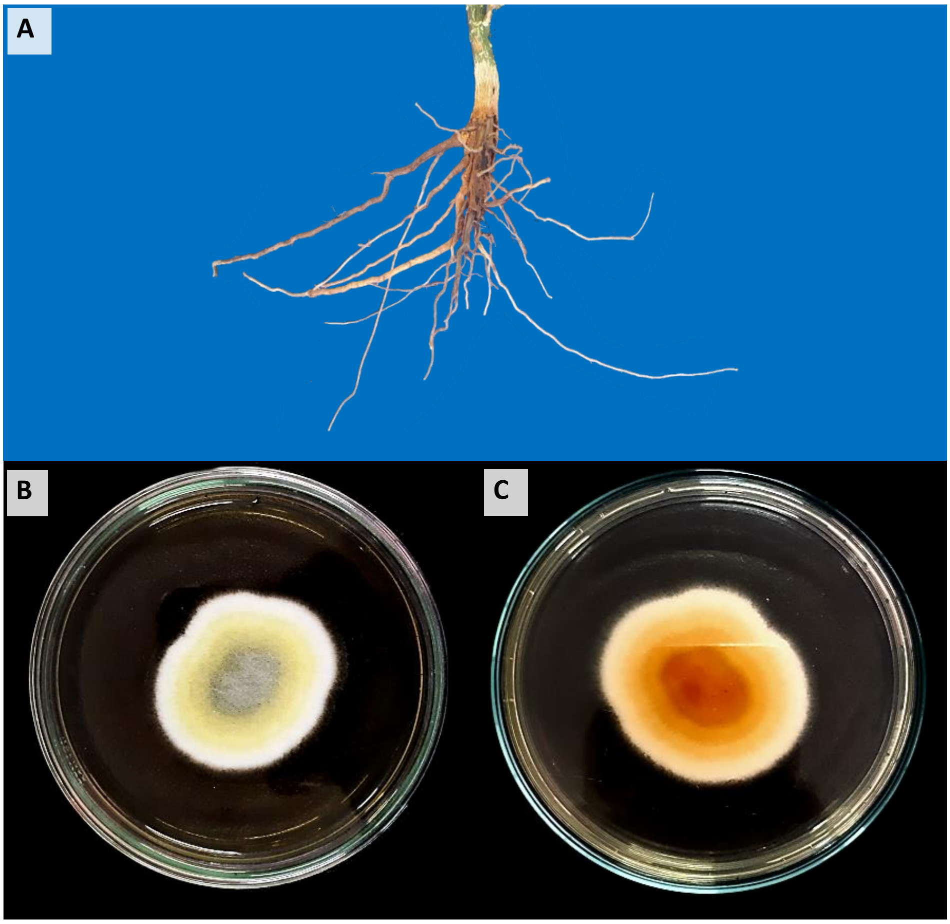
EVALUATION OF THE DISEASE INCIDENCE

A weekly survey of the number of dead plants was performed to evaluate the incidence of symptoms associated with *F. solani*. Every plant that started the process of wilting was considered dead, since this is an irreversible process (JESUS et al., 2016). In addition to the presence of wilt, we also looked for characteristic symptoms in the collar and root system.

Infected plants were easily detached from the soil, as a large part of the root system had already been necrotic and the few remaining roots became short, dark in color and brittle, due to the action of the fungus (Figure 3A). From this survey, the survival rate over time and the longevity of the plants were determined.

To confirm the etiological agent present on the area, the isolation of the fungus was carried out at the Laboratory of the IF Baiano, campus Guanambi, using material removed from the collar and roots of plants exhibiting the symptoms of the disease. Following isolation, a sample was sent to Embrapa Cassava and Fruits to confirm the presence of the pathogen on the area (Figure 3B and 3C).

Figure 3. Plant exhibiting symptom of collar and root rot (A); *F. solani* isolated from the area, front (B) and back (C) of a Petri plate. Guanambi – BA, 2019



Source: Created by the author.

STATISTICAL ANALYSIS

Data were subjected to analysis of variance, and interactions were further studied when significant. The means were compared using F- and Tukey tests for the factors planting system and species, respectively. Survival rate over time was analyzed using polynomial regression, at 5% significance.

RESULTS AND DISCUSSION

Passion fruit species, *P. edulis*, *P. cincinnata* and *P. foetida*, showed a significant interaction with the evaluation period ($p < 0.01$), as well as a significant interaction between species and management of the planting system – with or without partial exposure of the root system ($p < 0.01$), were observed for survival rate evaluated up to 140 DAT (Table 2). There was no triple interactions.

Table 2. Summary of the analysis of variance with the respective mean squares for survival rate up to 140 days after transplanting (DAT) of different passion fruit species on an area infested with *F. solani*, under planting system with and without partial exposure of the root system. Guanambi, Bahia, 2019

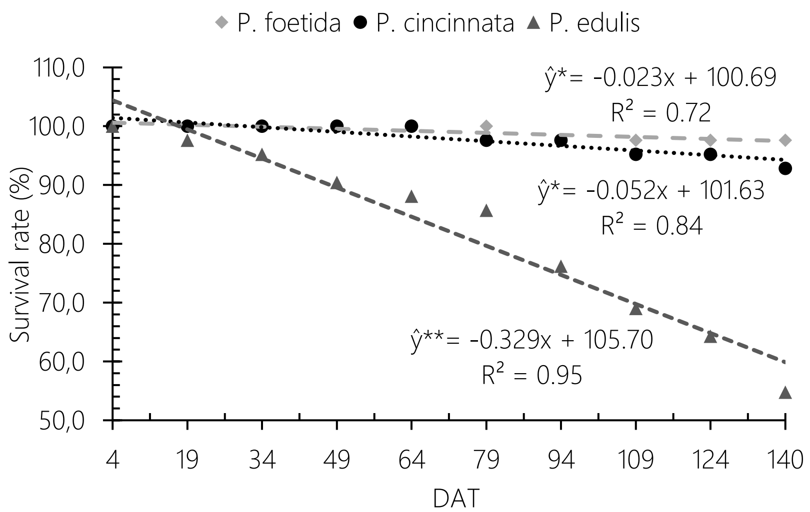
SV	DF	Mean squares
		Survival rate
Species (S)	2	5341.26**
Management (M)	1	1160.99**
DAT	9	722.60**
S x M	2	280.04**
S x DAT	18	371.50**
M x DAT	9	42.32^{NS}
S x M x DAT	18	34.39^{NS}
Blocks	2	280.04**
Residual	118	

SV, Source of variation; DF, degrees of freedom of residual error; DAT, days after planting; ^{NS}non-significant **significant at 1% of probability based on F-test. Source: Created by the authors

We recorded the first death of a *P. edulis* plant at 15 DAT; then, survival rate decreased linearly, 4.3% every 15 days, to a mean survival of 54.76% at 140 DAT (Figure 4). Conversely, the first *P. cincinnata* plant died only at 76 DAT (Figure 4), so the species may be classified as having moderate resistance to *F. solani* (SILVA et al., 2013; PREISIGKE et al., 2017). For *P. foetida*, a single death was recorded at 91 DAT (Figure 4), so it was classified as highly resistant (SILVA et al., 2013; PREISIGKE et al., 2015a; CARVALHO et al., 2021), with potential to be used as a rootstock for *P. edulis*.

Partial exposure of the root system reduced the mortality percentage for *P. edulis* plants, with a survival rate 23.8% higher than for plants without partial exposure of the root system, at 140 DAT. The species *P. foetida* and *P. cincinnata* performed better than *P. edulis*, both with and without the planting system with exposure of the root system (Figure 5). Both had a survival rate above 90%, with emphasis *on P. foetida*, with 100% survival rate when grown with the planting system with partial exposure of the roots (Figure 5).

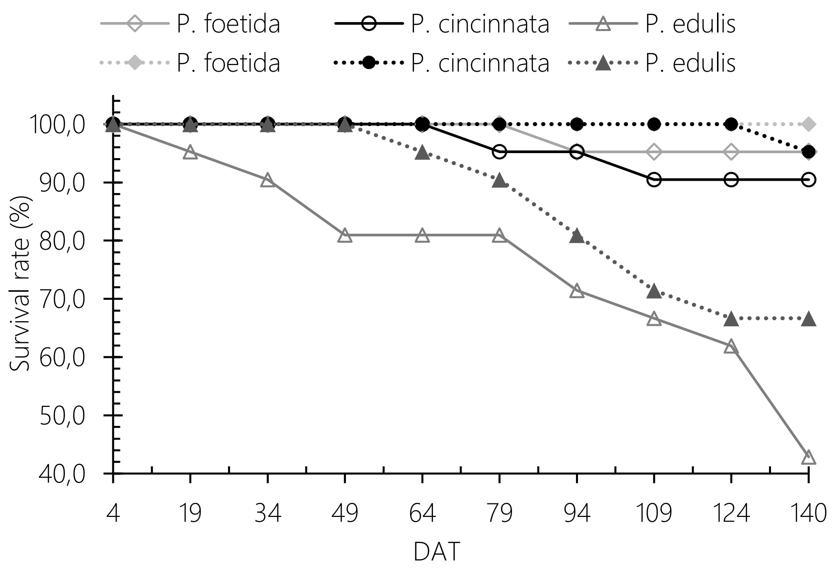
Figure 4. Mean survival rate of different passion fruit species on an area infested with *F. solani*, regardless of root system management, from January to June 2019, in Guanambi, Bahia, 2019.



*significant at 5% and **significant at 1% probability by Regression Analysis of Variance. Source: Created by the author.

Some authors, using survival analysis as a parameter, reported that yellow passion fruit had a low survival rate compared to other *Passiflora* species (LARANJEIRA et al., 2005; PREISIGKE et al., 2017); a similar result was reported for several hybrids and commercial cultivars (SILVA et al., 2017), which reinforces the need for technological alternatives for the cultivation of *P. edulis*.

Figure 5. Mean survival rate of different passion fruit species, on an area with history of *F. solani*, under planting system with exposure of the root system (sectioned lines and filled markers) and without exposure of the root system (solid lines and empty markers) from January to June 2019, in Guanambi, Bahia, 2019.



Source: Created by the authors.

The species *P. cincinnata* was reasonably tolerant to *F. solani*, showing a high survival rate. In other studies, it has been classified as a species with moderate to strong resistance on areas with a history of *F. solani* (SILVA et al., 2013; PREISIGKE et al., 2015b); however, it was considered susceptible when greenhouse-grown plants of different ages were inoculated with *F. solani* via the root system (FISCHER et al., 2005b).

Plants of *P. foetida* were resistant to *F. solani*, with only one record of mortality at 140 DAT. Positive responses were also reported in a work on comparing yellow passion fruit cultivars grafted on *P. foetida* grown on an area with a history of *F. oxysporum* f. sp. *passiflorae* in the region of Mossoró – RN. The authors reported 100% survival rate of grafted plants (SILVA et al., 2017). A similar result was observed in a study that evaluated the survival rate of plants and classified them according to a scale of evaluation of the disease, in which the intra- and interspecific variability of resistances against *F. solani* were confirmed, with *P. foetida* being evaluated as highly resistant (PREISIGKE et al., 2015a).

These results suggest that *P. foetida* is a promising species for use as a rootstock on soils with a history of *Fusarium* spp., as well as in plant breeding programs (SANTOS et al., 2011; PREISIGKE et al., 2015a; SILVA et al., 2017), thereby standing out as an alternative for passion fruit growers. However, different responses were reported by Roncatto et al. (2004), who describe this wild species as being susceptible to damping off, when evaluating different species of passion fruit on an area with unknown soil-borne pathogens, located at UNESP campus Jaboticabal, Brazil.

Therefore, further research is needed to evaluate its adaptation under different climatic and site conditions with a history of collar and root rot, and to verify its stability against the pathogen. The interaction of the plant with the fungus may be influenced by several soil and climate factors, as observed in the significant interaction between the species and the management of partial exposure of the roots.

The higher survival rate of *P. edulis* plants, when subjected to partial exposure of the root system, suggests that preventive measures may mitigate disease severity by improving the aeration of stem and roots and reducing the friction of these structures with the ground. The interactions of *F. solani* and the plant's root system are closely linked to the conditions of the root zone, since heavy and poorly drained soils favor the development of the disease (FISCHER et al., 2008).

Greater pathogenicity and aggressiveness of *F. solani* following changes in the aeration of the root zone have been reported for pea crop, which revealed fast mycelial growth of *F. solani* f. sp. *pisi* under anaerobic conditions, a 500% increase in growth and a 400% increase in root rot of inoculated peas (SMUCKER and ERICKSON, 1987). Furthermore, it has also been reported a greater severity of root rot in common bean, caused by *Fusarium solani* f. sp. *phaseoli*, under low O_2 conditions (ALLMARAS et al., 1988).

Given the above, it is necessary to use integrated actions aimed at increasing soil suppression to *F. solani*, prioritizing preventive measures that seek to improve environmental conditions for crop development. This can be accomplished by improving the aeration of the root system and plant collar and using growth-promoting microorganisms and antagonists against soil-borne pathogens.

CONCLUSIONS

Partial exposure of the root system reduces plant mortality caused by *F. solani*, 140 days after transplanting.

Passiflora foetida has, regardless of management, high resistance to *F. solani*.

ACKNOWLEDGEMENT

To the State University of Southwest Bahia, campus Vitória da Conquista, and Instituto Federal Baiano, campus Guanambi, for the resources, and to the Foundation for Research Support of the State of

Bahia, for granting a scholarship to the first author.

REFERENCES

ALLMARAS, R. R.; KRAFT, J. M. E MILLER, D. E. Effects of soil compaction and incorporated crop residue on root health. **Annual Review of Phytopathology**, v.26, p. 219-243, 1988.

BOMFIM, M. P.; SÃO JOSÉ, A.R.; REBOUÇAS, T. N. H.; ALMEIDA, S. S.; SOUZA, I. V. B.; DIAS, N. O. Avaliação antagônica *in vitro* e *in vivo* de *Trichoderma* spp. a *Rhizopus stolonifer* em maracujazeiro amarelo. **Summa Phytopathologica**, Botucatu, v.36, p. 61-67, 2010.

BORGES, A. L.; SOUZA, L. D. Recomendações de calagem e adubação para maracujazeiro. **Embrapa Mandioca e Fruticultura**: Comunicado Técnico, 141, Cruz das Almas: Embrapa Mandioca e Fruticultura, 2010, 4 p.

BRASIL. Ministério das Minas Energia. Secretaria Geral. **Projeto RAMBRASIL,** Folha SD 23 Brasília; geologia, geomorfologia, pedologia, vegetação e uso potencial da terra. Rio de Janeiro, 1982, v.29, 660 p.

BUENO, C. J.; FISCHER, I. H.; PARISI, M. C. M. FURTADO, E. L. Comportamento do maracujazeiro amarelo, variedade Afruvec, ante uma população de *Fusarium solani*, agente causal da podridão do colo e raiz. **Arquivos do Instituto Biológico**, São Paulo, v.77, n. 3, p. 533-537, 2010.

CARVALHO, J. A.; JESUS, J. G.; ARAUJO, K. L. SERAFIM, M. E.; GILIO, T. A. S.; NEVES, L. G. Passion Fruit (*Passiflora* spp.) species as sources of resistance to soil phytopathogens *Fusarium solani* and *Fusarium oxysporum* f. sp. *Passiflorae* complex. **Revista Brasileira de Fruticultura**, Jaboticabal, v.43, n. 1, (Versão digital), 2021. DOI: http://dx.doi.org/10.1590/0100-29452021427

CAVICHIOLI, J. C.; CORRÊA, L. S.; MARCHI, M. J.; FISCHER, I. H. Desenvolvimento, produtividade e sobrevivência de maracujazeiro-amarelo enxertado e cultivado em área com histórico de morte prematura de plantas. **Revista Brasileira de Fruticultura,** v.33, n. 2, p. 567-574, 2011.

FERREIRA, R. T.; VIANA, A. P.; SILVA, F. H. de L. e.; SANTOS, E. A.; SANTOS, J. O. Seleção recorrente intrapopulacional em maracujazeiro azedo via modelos mistos. **Revista Brasileira de Fruticultura,** Jaboticabal, v.38, p. 158-166, 2016.

FIGUEIREDO, F. R. A.; HAFLE, O. M.; RODRIGUES, M. H. B. S.; PEREIRA JÚNIOR, E. B.; DELFINO, F. I. Produtividade e qualidade dos frutos do maracujazeiro amarelo sob diferentes formas de condução de plantas. **Agropecuária Científica do Semiárido**, v.11, n.4, p. 23-32, 2015.

FISCHER, I. H.; REZENDE, J. A. M. Diseases of passion flower (*Passiflora* spp.). **Pest Technology,** v.2, p. 1-19, 2008.

FISCHER, I. H.; KIMATI, H.; REZENDE, J. A. M. Doenças do maracujazeiro (*Passifora* spp.). In: KIMATI, H.; AMORIM, L.; REZENDE, J. A. M.; BERGAMIN FILHO, A.; CAMARGO, L. E. A. (Ed.). **Manual de fitopatologia: Doenças das plantas cultivadas.** v.2, 4.ed. São Paulo: Agronômica Ceres, 2005a, p.467-474.

FISCHER, I. H.; LOURENÇO, S. A.; MARTINS, M. C.; KIMATI, H.; AMORIM, L. Seleção de plantas resistentes e de fungicidas para o controle da podridão do colo e raiz do maracujazeiro causada por *Nectria hematococca*. **Fitopatologia Brasileira,** v.30, n.3, p. 250-258, 2005b.

JESUS, O. N.; FALEIRO, F. G.; JUNQUEIRA, N. T. V.; GIRARDI, E. A.; ROSA, R. C. C.; PETRY, H. B. Cultivares comerciais de maracujá-azedo (*Passiflora edulis* Sims) no Brasil. In: JUNGHANS, T. G.; JESUS, O. N. de. **Maracujá do cultivo à comercialização,** Brasília – DF: EMBRAPA, 2017, p. 39-58.

JESUS, O. N. de; MARTINS, C.A.D.; OLIVEIRA, E. J.; SOARES, T. L.; FALEIRO, F.G.; BERNACCI, L.C.; MACHADO, C. de F.; GIRARDI, E. A.; ARAÚJO, F.P. de; PEREIRA, T.N.S.; VIANA, A.P.; JUNQUEIRA, N.T.V. **Descritores morfoagronômicos ilustrados para *Passiflora* spp.,** Embrapa, Brasília, DF., 2016. 122 p.

KUDO, A. S.; PEIXOTO, J. R.; JUNQUEIRA, N. T. V.; BLUM, L. E. B. Suscetibilidade de genótipos de maracujazeiro-azedo à septoriose em casa de vegetação. **Revista Brasileira de Fruticultura**, Jaboticabal, v. 34, n. 1, p. 200-205, 2012.

LARANJEIRA, F. F.; LIMA, A. A.; COSTA, M. M.; PFENNING, L. Progresso da fusariose do maracujá em porta-enxertos do gênero *Passiflora*. **Fitopatologia Brasileira**, Brasília, v.30, 2005, 146p.

MARCHIONATTO, J. B. Directivas en la lucha contra las enfermidades de las plantas. **Revista Argentina de Agronomia**, v.16, p. 29-32, 1949.

MAPA – Ministério da Agricultura Pecuária e Abastecimento. Base de dados AGROFIT. 2018. Disponível em: http://agrofit.agricultura.gov.br/agrofit_cons/principal_agrofit_cons. Acesso em: 04 jan. 2018.

MELETTI, L. M. M. Avanços na cultura do maracujá no Brasil. **Revista Brasileira de Fruticultura**, Jaboticabal, vol.33, n. spe1, p. 83-91, 2011.

PREISIGKE, S. C.; SILVA, L. P.; SERAFIM, M. E.; BRUCKNER, C. H.;

ARAÚJO, K. L.; NEVES, L. G. Seleção precoce de espécies de *Passiflora* resistente a fusariose. **Summa Phytopathologica,** v.43, n. 4, p. 321-325, 2017.

PREISIGKE, S. C.; VIAN, M. F.; ROSSI, A. A. B.; SERAFIM, M. E.; BARELLI, M. A. A.; LUZ, P. B.; ARAÚJO, K. L.; NEVES, L. G. Genetic variability of '*Passiflora*' spp. against collar rot disease, **Autralian Journal of Crop Science**, v.9, n. 1, 2015a. Disponível em: https://search.informit.com.au/documentSummary;dn=915279997314246;res=IELHS. Acesso em: 28 de junho de 2019.

PREISIGKE, S. C.; NEVES, L. G.; ARAÚJO, K. L.; BARBOSA, N. R.; SERAFIM, M. E.; KRAUSE, W. Multivariate analysis for the detection of *Passiflora* species resistant to collar rot. **Bioscience Journal,** Uberlândia, v.31, n. 6, p. 1700-1707, 2015b.

RONCATTO, G.; OLIVEIRA, J.C.; RUGGIERO, C.; NOGUEIRA FILHO, G.C.; CENTURION, M.A.P.C.; FERREIRA, F.R. Comportamento de maracujazeiros (*Passiflora* spp.) quanto à morte prematura. **Revista Brasileira de Fruticultura**, Jaboticabal, v.26, n. 3, p. 552-554, 2004.

SÃO JOSÉ, A. R.; BOMFIM, M. P.; HOJO, R. H.; ANGEL, D. N.; PIRES, M. de M. Doenças do maracujazeiro. In: PIRES, M. M.; SÃO JOSÉ, A. R.; CONCEIÇÃO, A. O. **Maracujá:** avanços tecnológicos e sustentabilidade. Ilhéus: Editus, 2011, p. 115-146.

SANTOS FILHO, H. P.; BARBOSA, F. F. L.; HADDAD, F. Doenças do maracujazeiro causadas por fungos, oomicetos e bactérias. In: JUNGHANS, T. G.; JESUS, O. N. de. **Maracujá do cultivo à comercialização,** Brasília – DF: EMBRAPA, 2017, p.39-58.

SANTOS, E. A.; SOUZA, M. M.; VIANA, A. P.; ALMEIDA, A. A. F.; FREITAS, J. C. O.; LAWINSCKY, P. R. Multivariate analysis of morphological characteristics of two species of passion flower with ornamental potential and of hybrids between them. **Genetics and Molecular Research**, Ribeirão Preto, v.10, n. 4, p. 2457-2471, 2011.

SILVA, R. M.; AMBRÓSIO, M. M. Q.; AGUIAR, A. V. M.; FALEIRO, F. G.; CARDOSO, A. M. S.; MENDONÇA, V. Reaction of passion fruit cultivars in areas with fusariosis. **Summa Phytopathologica,** v.43, n.2, p.98-102, 2017.

SILVA, A. N.; AZEVEDO, G. B.; ROCHA SOBRINHO, G. G.; NOVAES, Q. S. Efeito de produtos químicos e de *Trichoderma* spp. no controle de *Fusarium solani* do maracujazeiro. **Interciencia**, v.39, n. 6, p. 398-403, 2014.

SILVA, A. S.; OLIVEIRA, E. J.; HADDAD, F.; LARANJEIRA, F. F.; JESUS, O. N.; OLIVEIRA, S. A. S.; COSTA, M. A. P. C.; FREITAS, J. P. X.

Identification of passion fruitn genotypes resistant to *Fusarium oxysporum* f. sp. *passiflorae*. **Tropical Plant Pathology,** Brasilia, v.38, n. 3, p. 236-242, 2013.

SMUCKER, A. J. M., ERICKSON, A. E. Anaerobic stimulation of root exudates and disease of peas. **Plant Soil,** v.99, p. 423-433, 1987.