CROP BREEDING AND APPLIED BIOTECHNOLOGY

CULTIVAR RELEASE

Solar: a new sour passion fruit cultivar for the state of Mato Grosso

Leandro Rafael Fachi[1], Willian Krause[2*], Leonarda Grillo Neves[3], Petterson Baptista da Luz[3], Celice Alexandre Silva[2] and Dejânia Vieira de Araújo[2]

Crop Breeding and Applied Biotechnology
21(4): e38682146, 2021
Brazilian Society of Plant Breeding.
Printed in Brazil
http://dx.doi.org/10.1590/1984-70332021v21n4c55

Abstract: *Cultivar Solar was developed specifically for the edaphoclimatic conditions of the State of Mato Grosso. It has improved fruit physical and chemical characteristics, such as higher fruit weight, total soluble solids content and pulp percentage, and is suitable for both fresh consumption and processing industry.*

Keywords: *Passiflora edulis Sims, breeding, innovation*

INTRODUCTION

Passion fruit plants of the species *Passiflora edulis* Sims are widely grown in Brazil and in other tropical countries such as Peru, Ecuador, Venezuela, Colombia, Australia, and India; passion fruit can be consumed fresh or in juice from concentrate (Faleiro et al. 2015). Brazil is the center of origin and the largest producing country of sour passion fruit. With approximately 153 native species, the country is the second diversity center of the genus *Passiflora*, after Colombia with approximately 170 native species (Bernacci et al. 2013). In addition, passion fruit consumption is highest in Brazil, which indicates the importance of this crop for the country (Borges et al. 2019).

In 2019, Brazil produced 593.429 Mg of sour passion fruit on 41.584 ha (IBGE 2019). In the state of Mato Grosso, passion fruit production has expanded, with an acreage increase of 261% between 2001 and 2019. The crop is a promising option for small growers, in view of the high return per area. Approximately 104.000 family farms in Mato Grosso can benefit from passion fruit crops, as a significant part of their income. However, the overall output of the state (16.4 Mg ha^{-1}) is lower than in other producing regions, e.g., the Federal District (27.68 Mg ha^{-1}). This low yield has usually been attributed to the lack of regionally adapted cultivars, fragmentary application of modern production technology and phytosanitary problems (Santos et al. 2011). Moreover, passion fruit crops are affected by a significant genotype-environment interaction (Krause et al. 2012), which reinforces the need for region-specific breeding programs.

In this sense, passion fruit breeding programs have developed lines with morphological, physiological and agronomic characteristics that boost productivity and quality and ensure high yield stability (Krause et al. 2012, Ocampo et al. 2016, Cavalcante et al. 2017). In addition, aside from high fruit yield and quality, new cultivars should also have strong growth, vigor, disease tolerance and resistance to adverse weather to ensure market acceptance (Souza et al. 2012, Zucareli et al. 2014). Only 13 sour passion fruit cultivars are currently available

***Corresponding author:**
E-mail: krause@unemat.br
ORCID: 0000-0002-5308-7715

Received: 09 July 2021
Accepted: 08 October 2021
Published: 25 November 2021

[1] Universidade Federal de Mato Grosso (UFMT), Instituto de Biociências, Campus Cuiabá, 78.060-900, Cuiabá, MT, Brazil
[2] Universidade do Estado de Mato Grosso (Unemat), Departamento de Agronomia, Campus Tangará da Serra, 78.300-970, Tangará da Serra, MT, Brazil
[3] Universidade do Estado de Mato Grosso (Unemat), Departamento de Agronomia, Campus Cáceres, 78.200-000, Tangará da Serra, MT, Brazil

on the seed market. In view of the high diversity of agroecosystems in Brazil, this is insufficient to meet the demand (MAPA 2020).

In 2009, the State University of Mato Grosso (UNEMAT) started a sour passion fruit breeding program focused on developing a cultivar adapted to the conditions of the state. As a result, this study presents the main characteristics of Solar, a new passion fruit cultivar for Mato Grosso, Brazil.

ORIGIN AND BREEDING METHOD

The UNEMAT breeding program of sour passion fruit was initiated in 2009. Figure 1 shows the main phases, based on the intrapopulation recurrent selection method. Initially, seven commercial cultivars (BRS Gigante Amarelo, BRS Rubi do Cerrado, BRS Sol do Cerrado, BRS Ouro Vermelho, FB 100, FB 200, IAC 275) were crossed with each other. A statistical genetic analysis using the restricted maximum likelihood/best linear unbiased prediction (REML/BLUP) was carried out, for which individual plants were selected and recombined to establish population UNEMAT-01 (Assunção et al. 2015). From this base population, 118 full-sib families were derived, among which 30 families were selected and recombined for population UNEMAT-02 (Dalbosco et al. 2018).

2009	Cross of seven sour passion fruit genotypes (BRS Gigante Amarelo, BRS Rubi do Cerrado, BRS Sol do Cerrado, BRS Ouro Vermelho, FB 100, FB 200, IAC 275)
	⬇
2011	Evaluation of the crosses for agronomic characteristics in a randomized block design, with individual plant evaluation.
	⬇
2013	Individual selection of the 30 best plants based on REML/BLUP and recombination for the formation of population UNEMAT-01
	⬇
2014	Obtaining and morpho-agronomic evaluation of 118 full-sib families
	⬇
2015	Selection of 30 full-sib families by the restrictive selection index
	⬇
2017	Recombination and formation of population UNEMAT-02 (cv. Solar)
	⬇
2019-20	Evaluation of cultivar Solar

Figure 1. Flowchart of intrapopulation recurrent selection of the UNEMAT sour passion fruit breeding program.

Population UNEMAT-02 (cultivar Solar) and the commercial passion fruit cultivars FB 200, FB 300, UENF Rio Dourado, BRS Sol do Cerrado, and Maracujá Amarelo (Feltrin Seeds) were evaluated at the experimental station of the University (lat 14° 39' S, long 57° 25' W, alt 321 m asl), Tangará da Serra, MT. Seeds were planted in January 2019, at a spacing of 3.0 m between plants and crop rows, to allow agricultural traffic in the experimental area. A vertical trellis system was used, with cordon wires (number 12) extended between 2.5 m high stalks spaced 6.0 m apart, beginning at 2.0 m from the ground. Cultural practices such as irrigation, soil fertilization, pruning and pest and disease control were carried out as recommended for passion fruit; no artificial pollination was used (Costa et al. 2008).

The characteristics of distinguishability, homogeneity, and stability for passion fruit (*Passiflora edulis* Sims) of the new cultivar were determined as proposed by the National Cultivar Protection Service of the Brazilian Ministry of Agriculture, Livestock, and Supply (SNPC - MAPA 2016). Twelve plants of each cultivar were evaluated based on morpho-agronomic characteristics of nine leaves, flowers, and fruits per plant of each cultivar.

Table 1. Means and standard deviation of the main quantitative fruit characteristics of cv. Solar, compared with five commercial passion fruit cultivars

Cultivars	**FW** (g)	**FL** (mm)	**FD** (mm)	**ST** (mm)	**TSS** (°Brix)	**PP** (%)
Solar	209.9 ± 21.7 a	100.3 ± 8.4 a	86.8 ± 5.5 a	5.9 ± 0.7 b	14.7 ± 0.9 a	36.9 ± 3.2 a
FB 200	208.8 ± 27.9 a	88.5 ± 7.2 c	77.5 ± 7.2 b	5.6 ± 2.1 b	13.1 ± 2.4 a	29.9 ± 6.2 b
FB 300	227.7 ± 56.4 a	80.1 ± 7.1 d	73.9 ± 6.7 b	4.8 ± 1.0 a	12.7 ± 1.8 a	30.1 ± 4.6 b
UENF Rio Dourado	202.0 ± 46.8 a	85.2 ± 9.5 c	78.9 ± 6.9 b	4.2 ± 0.8 a	13.1 ± 1.6 a	28.8 ± 5.5 b
BRS Sol do Cerrado	183.0 ± 35.7 a	95.8 ± 10.9 b	80.2 ± 6.7 b	5.4 ± 1.2 b	13.0 ± 2.5 a	29.7 ± 6.3 b
Maracujá Amarelo	205.1 ± 37.0 a	92.1 ± 4.6 b	85.8 ± 6.4 a	5.3 ± 0.9 b	12.5 ± 1.9 a	30.5 ± 7.9 b

FW: fruit weight; FL: fruit length; FD: fruit diameter; ST: fruit skin thickness; TSS: total soluble solids content; PP: pulp percentage. Means followed by the same letter in a column do not differ from each other by the Scott-Knott test at 5% probability.

CHARACTERISTICS AND PERFORMANCE OF CULTIVAR SOLAR

The fruit weight of cultivar Solar (209.9 g), statistically similar to that of the other evaluated cultivars, was adequate for marketing (Table 1). However, cv. Solar had the longest and, together with cv. Maracujá Amarelo, the thickest fruits. According to the Brazilian program to improve commercial standards and packaging of horticulture products (Brasil 2011), passion fruit classes are scored on a numeric scale (1-5), based on the fruit diameter. Thus, the studied cultivars were assigned to Class 5 (≥85 mm), which is considered an optimal classification. The skin thickness of cv. Solar fruits is high (5.9 mm), which is advantageous for fresh fruit, for avoiding post-harvest damage during transport.

The total soluble solid (TSS) content is another important characteristic of passion fruit. The TSS contents of the investigated cultivars were similar (12.5 - 14.7 °Brix). This indicates the fruits of all tested cultivars as suitable for the processing industry, which accepts fruits with °Brix > 11 (Brasil 2011). For the industrial use of passion fruit, high TSS contents are needed, mainly for concentrate or pulp production. According to Nascimento et al. (2003), 11 kg of fruit with °Brix between 11 and 12 are needed for the industrial production of 1 kg concentrate for juice with 50 °Brix. In other words, the higher the TSS content, the lower the quantity of fruits needed to obtain a specific amount of concentrate; thus, the use of fruits with high °Brix increases the efficiency of industrial processing and decreases production costs. Of all studied cultivars, cv. Solar had the highest pulp percentage (36.92%), exceeding the recommended 33% for processing (Nascimento et al. 1999). Although cv. Solar is a population, the standard deviations for traits fruit weight and fruit skin thickness were the lowest (Table 1), indicating high homogeneity for these traits.

OTHER CHARACTERISTICS

The fruit shape of cv. Solar is mostly oval, the skin yellow and pulp orange (Figure 2). Table 2 presents the results found for morpho-agronomic characteristics related to branch, leaf, and flowers.

In summary, the results show the potential of cv. Solar as a new alternative option of sour passion fruit for passion fruit growers in the state of Mato Grosso, Brazil.

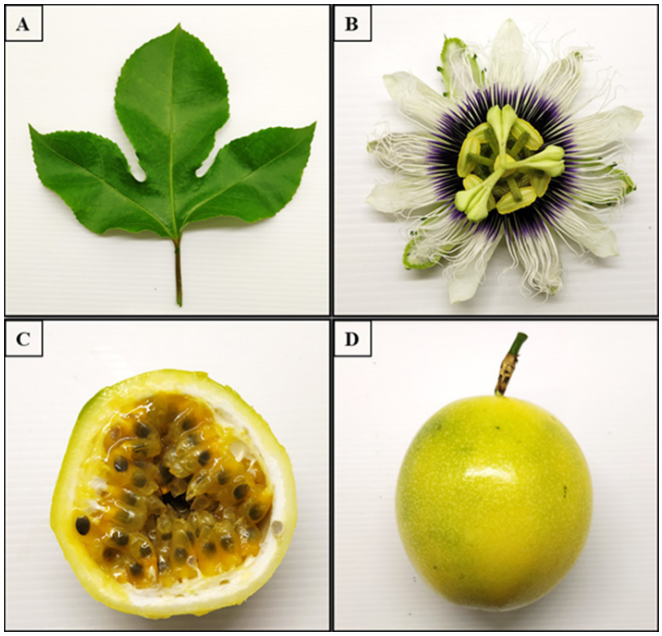

Figure 2. Predominant appearance of A: leaves; B: flowers, with completely curved styles; C: interior view; and D: external view of fruit of cultivar Solar.

Table 2. Characteristics of branch, leaf, and flower of the passion fruit cultivar Solar

Leaf and branch characteristics	
Length of leaf blade leaf (mm)	157.3
Maximum leaf blade width (mm)	174.5
Predominant branch color	Dark green
Leaf blade sinus depth	Mean
Leaf blade bulging	Present
Position of leaf petiole nectaries	Adjacent
Flower characteristics	
Petiole length	65.7
Flower bract length	33.5
Flower sepal length	40.5
Flower sepal width	14.6
Flower diameter	98.9
Flower corona diameter	79.8
Flower ring width	13.4
Flower androgynophore length	11.5
Flower corona filaments	Wavy
Colored corona rings	Present
Corona ring color	Dark purple
Anthocyanin in the flower androgynophore	Absent / Weak
Anthocyanin in the flower fillet	Absent / Weak
Anthocyanin in the flower style	Absent / Weak

SEED REGISTRATION, PRODUCTION, AND DISTRIBUTION

The sour passion fruit cultivar Solar was registered by the Brazilian Ministry of Agriculture, Livestock, and Supply, under number 42313, upon request of the State University of Mato Grosso (UNEMAT) in partnership with the company Feltrin Seeds Ltd., since genetic seed stocks are maintained by both Institutions.

ACKNOWLEDGMENTS

The authors thank the Research Support Foundation of the State of Mato Grosso (FAPEMAT), Brazilian National Council for Scientific and Technological Development (CNPq) and Brazilian Federal Agency for Support and Evaluation of Graduate Education (CAPES) for funding the program and for scientific initiation, master, and doctoral scholarships of students working in the sour passion fruit breeding program of the State University of Mato Grosso (UNEMAT).

REFERENCES

Assunção MP, Krause W, Dallacort R, Santos PRJ and Neves LG (2015) Seleção individual de plantas de maracujazeiro azedo quanto à qualidade de frutos via REML/BLUP. **Revista Caatinga 28**: 57-63.

Bernacci LC, Cervi AC, Milward-de-Azevedo MA, Nunes TS, Imig DC and Mezzonato AC (2013) Lista de espécies da flora do Brasil: Passifloraceae. Jardim Botânico, Rio de Janeiro. Available at: <http://floradobrasil.jbrj.gov.br/jabot/floradobrasil/FB182>. Accessed on July 08, 2021.

Borges JD, Tonon DS and Silva DJ (2019) Produção e comercialização do maracujá-azedo em Tangará da Serra/MT, Brasil: desafios, fragilidades e oportunidades. **Revista Ibero-Americana de Ciências Ambientais 10**: 10-24.

Brasil - Ministério da Integração Nacional (2011) Programa brasileiro para a melhoria dos padrões comerciais e embalagens de horticultura. Available at: <www.integracao.gov.br>. Accessed on November 11, 2020.

Cavalcante NR, Krause W, Viana AP, Silva CA, Porto KKX and Martinez RAS (2017) Anticipated selection for intrapopulation breeding of passion fruit. **Acta Scientiarum. Agronomy 39**: 143-148.

Costa AFS, Costa AN, Ventura JA, Fanton CJ, Lima IM, Caetano LCS and Santana EN (2008) **Recomendações técnicas para o cultivo do maracujazeiro**. Incaper, Vitória, 56p. (Documentos, 162).

Dalbosco EZ, Krause W, Neves LG, Araújo DV, Hiega KMR and Silva CG (2018) Parametric and non-parametric indexes applied in the selection of sour passion fruit progenies. **Revista Brasileira de Fruticultura 40**: e-282.

Faleiro FG, Junqueira NTV and Costa AM (2015) **Ações de pesquisa e desenvolvimento para o uso diversificado de espécies comerciais e silvestres de maracujá (*Passiflora* spp.)**. Embrapa Cerrados, Planaltina, 26p.

IBGE - Instituto Brasileiro de Geografia e Estatística (2019) Sistema IBGE de recuperação automática - SIDRA. Available at <https://sidra.ibge.gov.br/pesquisa/pam/tabelas> Accessed on August 3, 2020.

Krause W, Souza RS, Neves LG, Silva Carvalho ML, Viana AP and Faleiro FG (2012) Ganho de seleção no melhoramento genético intrapopulacional do maracujazeiro-amarelo. **Pesquisa Agropecuária Brasileira 47**: 51-57.

MAPA - Ministério da Agricultura, Pecuária e Abastecimento (2020) Available at <http://sistemas.agricultura.gov.br/snpc//cultivarweb/> Accessed on August 3, 2020.

Nascimento TB, Ramos JD and Menezes JB (1999) Características físicas do maracujá-amarelo produzido em diferentes épocas. **Pesquisa Agropecuária Brasileira**. **34:** 2353-2358.

Nascimento WMO, Tomé AT, Oliveira MSP and Carvalho JEU (2003) Seleção de progênies de maracujazeiro-amarelo (*Passiflora edulis* f, flavicarpa) quanto à qualidade de frutos. **Revista Brasileira de Fruticultura 25:** 186-188.

Ocampo J, Arias JC and Urrea R (2016) Interspecific hybridization between cultivated and wild species of genus *Passiflora* L. **Euphytica 209**: 395-408.

Santos CEM, Bruckner CH, Cruz CD, Siqueira DL and Rosado LDS (2011) Componentes genéticos aditivos e não aditivos em maracujazeiro-azedo. **Pesquisa Agropecuária Brasileira 46**: 482-490.

SNPC - MAPA (2016) Frutíferas. Available at <https://www.gov.br/agricultura/pt-br/assuntos/insumos-agropecuarios/insumos-agricolas/protecao-de-cultivar/frutiferas> Accessed on August 5, 2020.

Souza SAM, Martins KC, Azevedo AS and Pereira TNS (2012) Fenologia reprodutiva do maracujazeiro-azedo no município de Campos dos Goytacazes, RJ. **Ciência Rural 42**: 1774-1780.

Zucareli V, Ono EO, Boaro CSF and Brambilla WP (2014) Desenvolvimento inicial de maracujazeiros (*Passiflora edulis f. flavicarpa, P. edulis f. edulis* e *P. alata*) enxertados sobre *Passiflora cincinnata*. **Semina: Ciências Agrárias 35**: 2325-2339.