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SCIENTIFIC COMMUNICATION

GROWTH, FRUIT SET, AND FUSARIOSIS REACTION OF YELLOW PASSION FRUIT GRAFTED ONTO *Passiflora* spp.[1]

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ABSTRACT – Yellow passion fruit grafting on other *Passiflora* spp. may be an alternative technique for the production under biotic stresses, especially soil-borne diseases. This study evaluated the survival of yellow passion fruit to fusariosis grafted onto *P. edulis*, *P. alata*, *P. gibertii* and *P. cincinnata*, in the field in Cruz das Almas, State of Bahia, Brazil. Horticultural performance was evaluated as plant growth, flowering and fruit set up to 13 months after transplanting. The apical cleft hipocotyledonar grafting was used. Survival analysis to fusariosis was based on the detection of typical visual symptoms. Grafting in species of wild passifloras did not influence on the stem diameter or fruit set of the yellow passion fruit, even though the flowering of *P. edulis* grafted on *P. alata* was lower than *P. edulis* grafted on itself. Hipocotyledonar grafting of *P. edulis* on *P. gibertii*, *P. cincinnata* and *P. alata* resulted in similar survival rates to fusariosis in relation to plants grafted onto *P. edulis* up to 13 months after transplanting.
Index terms: *Passiflora* spp., *Fusarium oxysporum* f. sp. *passiflorae*, performance, propagation.

CRESCIMENTO, FRUTIFICAÇÃO E REAÇÃO A FUSARIOSE EM MARACUJAZEIRO AZEDO ENXERTADO EM *Passiflora* spp.

RESUMO – A enxertia do maracujazeiro azedo em outras espécies de *Passiflora* spp. pode ser uma alternativa para a produção sob estresses bióticos, notadamente doenças do sistema radicular. Este trabalho avaliou a reação à fusariose de maracujazeiro azedo enxertado em *P. edulis*, *P. alata*, *P. gibertii* e *P. cincinnata* em condições de campo em Cruz das Almas, BA. O desempenho agronômico foi avaliado pelo crescimento, florescimento e produção de frutos até 13 meses após o plantio. A enxertia foi do tipo garfagem hipocotiledonar de topo em fenda cheia. Procedeu-se à análise de sobrevivência à fusariose ao longo do período de avaliação, baseando-se em sintomas visuais da doença. A enxertia em espécies de passifloras silvestres não alterou o diâmetro do caule nem a frutificação do maracujazeiro azedo, embora o florescimento de *P. edulis* enxertado em *P. alata* tenha sido inferior ao observado em *P. edulis* enxertado em si mesmo. A enxertia hipocotiledonar de *P. edulis* em *P. gibertii*, *P. cincinnata* e *P. alata* resultou em sobrevivência à fusariose similar às plantas enxertadas em *P. edulis* até 13 meses após o plantio a campo.
Termos para indexação: *Passiflora* spp*.*, *Fusarium oxysporum* f. sp. *passiflorae*, desempenho, propagação.

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Brazil stands out as the largest producer of passion fruit, *Passiflora edulis* Sims (yellow-passion fruit) the species with high commercial value (MELETTI, 2011). In 2014, the Brazilian production was 823,284 tons with 71% of the total concentrated in the Northeast region (IBGE, 2015). The state of Bahia stood out for having 46% of the planted area with 30,657 ha.

Although the state of Bahia stands out as the largest national producer, the crop in this region has low productivity (12.43 t ha^{-1}) (IBGE, 2015) when compared to the crop production potential, estimated at 40 to 50 t ha^{-1} (FREITAS et al., 2011). Among the factors that limit the productivity, the high incidence of disease is crucial because in general there are no varieties of yellow passion fruit with satisfactory resistance (MELETTI, 2011; OLIVEIRA et al., 2013). Among the diseases, it can be highlighted those caused by the fungus *Fusarium oxysporum* f. sp. *passiflorae* and *Fusarium solani*. The first causes fusariosis or the fusarium wilt, characterized by necrosis of the vascular system causing shoot wilts, collapse and death of plants in any stage of development, while the second causes stem and root system rot (FISCHER and REZENDE, 2008; BUENO et al., 2014).

The grafting of yellow passion fruit on resistant species is reported as an alternative method that can overcome this problem, so similar to that observed in other crops, such as the root rot caused by *Phytophthora* spp. in citrus (NOGUEIRA FILHO et al., 2011). It can also contribute to the deploying of technically superior orchards, either due to rootstocks resistant to disease or getting less heterogeneous orchards, more productive and with more uniform fruits (RONCATTO et al., 2011).

Most studies published on grafting on different species of *Passiflora* spp. evaluated the stage of seedlings formation, considering the living grafts. In some cases they studied field agronomic performance, besides the compatibility between species and incidence of fusariosis (NOGUEIRA FILHO et al., 2011; RONCATTO et al., 2011). The results are varied according to the grafting method, species, time of the year, isolated of the causative agent and place of study. Thus, it is necessary to expand the evaluation of the use of rootstocks for yellow passion fruit that can induce greater resistance to biotic stresses and suitable agronomic performance.

The objective of this study was to evaluate the growth the fruiting, and the reaction to fusariosis on yellow passion fruit grafted in *Passiflora* spp. in the Bahia Reconcavo.

The experiment was conducted from January 2012 to February 2013 in the experimental field of Embrapa Cassava and Fruit Crops, in Cruz das Almas, BA (12º 40 ‘12 “S, 39 06’ 07” W, 220 m). According to the Köppen classification, the climate is a transition type Am a Aw (tropical sub-humid to dry), with average annual air temperature of 23.8ºC, annual average rainfall of 1,224 mm, with the highest concentration from June to August, and average relative air humidity of 82.3%.

We evaluated four species as rootstocks of yellow passion fruit: *P. alata* (BGP004), *P. gibertii* N. E. (BGP008), *P. cincinnata* Mast. (BGP268) and *P. edulis* (GP09-03). As canopy (graft), it was used the passion fruit *P. edulis* ‘GP09-03’. The genotypes were selected by the Genetic Improvement Program of Embrapa Cassava & Fruits.

The seeds were germinated in plastic bags of 250 ml containing commercial substrate base of decomposed pine bark (Plantmax®). The seedlings were then kept in greenhouse protected with 25% shading and watered four times a day to 2 L m^{-2} for 10 min and with a nutrient solution containing calcium nitrate at 1.5 g L^{-1}. Grafting was performed on the type apical cleft hipocotyledonar grafting, 55 days after emergence, when the rootstocks and the grafts had on average four to five true leaves, 2 mm stem diameter and 10 to 15 cm height as described by Roncatto et al. (2011).

Ninety days after grafting, the seedlings were selected for similarity in size (25 to 30 cm, 3.5 mm stem diameter and eight leaves on average) and transplanted into the experimental area with fusariosis history of passion fruit (*Fusarium oxysporum* f. sp. *passiflorae*) (Oliveira et al., 2013). It was also used artificial inoculation in the field planting, adding 100g of substrate by sand and cornmeal method colonized by *Fusarium oxysporum* f. sp. *passiflorae* in the pit bottom, using the isolated Fop002 obtained from plants infected with typical symptoms of the disease at Embrapa Cassava and Fruit Crops experimental area and stored in the mycology collection of the Phytopathology Laboratory of the same institution, according to the procedures described by Silva et al. (2011).

The cultivation was conducted in espalier of 2.0m height and wire threads spacing 3.0m x 2.0m, with drip irrigation. Cultural practices usually recommended to the cultivation of passion fruit were followed (LIMA et al., 2011); however there was no control of any diseases after transplanting.

The variables evaluated have included the stem diameter, 10 cm above the colon, corresponding to the rootstock, and the number of flowers and fruits accumulated per plant, 13 months after transplanting. The incidence of plants with visual symptoms of *Fusarium oxysporum* f. sp. *passiflorae* wilt (FISHER and RESENDE, 2008) was evaluated monthly up to 13 months after transplantation, in percentage terms. Whenever typical symptoms of fusariosis were identified, sample of the root system and part of the symptomatic stem of each plant was collected, proceeding to isolation to confirm the presence of the causal agent; the colonies were evaluated after five days to macro and microconides according to the method described by Silva et al. (2013).

The experimental design was completely randomized, with five treatments that corresponded to the four *P. edulis* treatments grafted in passiflora and one control, ungrafted of *P. edulis*. They used 90 repetitions for plants evaluated as rootstock and 30 repetitions for plants evaluated as ungrafted, with one plant per plot. When necessary to fulfill the standardization and homogenization of variances, the data were subjected to angular transformation arcsine of the square root of (x+0.5)/100. The results were submitted to analysis of variance and means were compared by the SNK test ($P \leq 0.05$).

As fusariosis results in the death of the symptomatic plants immediately after its manifestation, survival analysis was applied as statistical tool for this disease incidence data (SILVA et al., 2013). In this case, the survival time was the time between the first exposure of the plants until the occurrence of the symptoms. For each treatment was generated a Kaplan-Meier curve. This curve shows the dynamics of the probability of a given plant does not present symptoms in a given time period. These curves were compared among themselves by the F test by Cox ($P \leq 0.01$).

The stem diameter and the number of accumulated fruits were not influenced by *P. edulis* grafting on wild passiflora, while the number of accumulated flowers of *P. edulis* grafted on *P. alata* was lower than in *P. edulis* grafted on itself (Table 1). Nogueira Filho et al. (2011) also observed that *P. edulis* grafted on *P. alata* showed lower flower yield potential than *P. edulis* grafted on itself and on *P. cincinnata*.

The symptoms of fusariosis started eight months after transplanting, in all treatments, and the survival at 13 months was not influenced by rootstock (Figure 2), with an average rate of 61.25%. All the samples collected during the study confirmed the isolation of *Fusarium oxysporum* f. sp. *passiflorae* as causal agent of the disease observed.

Laranjeira et al. (2005), using similar methodology, have noted that *P. edulis* was the most susceptible species to fusariosis as compared to *P. edulis* grafted on *P. alata*, *P. cincinnata* and *P. gibertii*, getting conflicting results with those obtained in this study. A higher level of genetic resistance of *P. edulis* access used could be considered, since there is variation in genotypes resistance in the same *Passiflora* species (SILVA et al., 2013). However, when evaluated as canopy variety, this access also showed mortality.

Another explanation for the incidence of fusariosis in grafted plants in wild species is that the grafting has been very low, leaving the stem of *P. edulis* in contact with the infested soil allowing its infection by the *Fusarium* spp.. Performance reports of grafted plants in Kenya have shown that yellow passion fruit, considered in that country as more resistant to fusarium wilt, has been successfully used as rootstock for purple passion fruit (AMATA et al., 2009).

The hypocotyledonary grafting technique did not reduce the total content of plant death after 13 months after transplanting, even when assessing species considered more tolerant of fusariosis, in relation to *P. edulis*, as rootstock (SILVA et al., 2013). This implies the need to evaluate a greater number of genotypes of *Passiflora* spp. for the survival to fusariosis in different growing conditions, as well as exploration of hybrid between *P. edulis* and other species that result in better performance as rootstock. These results also suggest that other studies evaluating higher grafting in relation to the rootstock colon are necessary to validate this technique as fusariosis control.

In conclusion, the grafting of wild passiflora species did not change the stem diameter or fruiting of yellow passion fruit, although the flowering of *P. edulis* grafted on *P. alata* has been lower than that observed in *P. edulis* grafted in itself. Hypocotyledonary grafting of *P. edulis* on *P. gibertii*, *P. cincinnata* and *P. alata* resulted in survival of fusariosis similar to that plants grafted on *P. edulis*, up to 13 months after field planting.

TABLE 1 - Number of flowers and fruits accumulated per plant and stem diameter of yellow passion fruit plant (*Passiflora edulis* Sims) grafted on different species of *Passiflora* and *Passiflora edulis* Sims grown as ungrafted, 13 months after field transplanting.

Rootstock	Number of flowers accumulated	Number of fruits accumulated	Stem diameter (mm)
P. alata	4 b	2 a	12.8 a
P. cincinnata	17 ab	12 a	15.2 a
P. edulis	43 a	14 a	15.0 a
P. gibertii	30 ab	5 a	10.5 a
P. edulis (ungrafted)	36 ab	11 a	14.9 a
CV (%)	27.8	38.6	10.1
F values	4.67*	2.04^{ns}	1.71^{ns}

ns and * respectively not significant and significant at $P \leq 0.05$.
Means followed by different letters in the column differ by SNK test ($P \leq 0.05$)

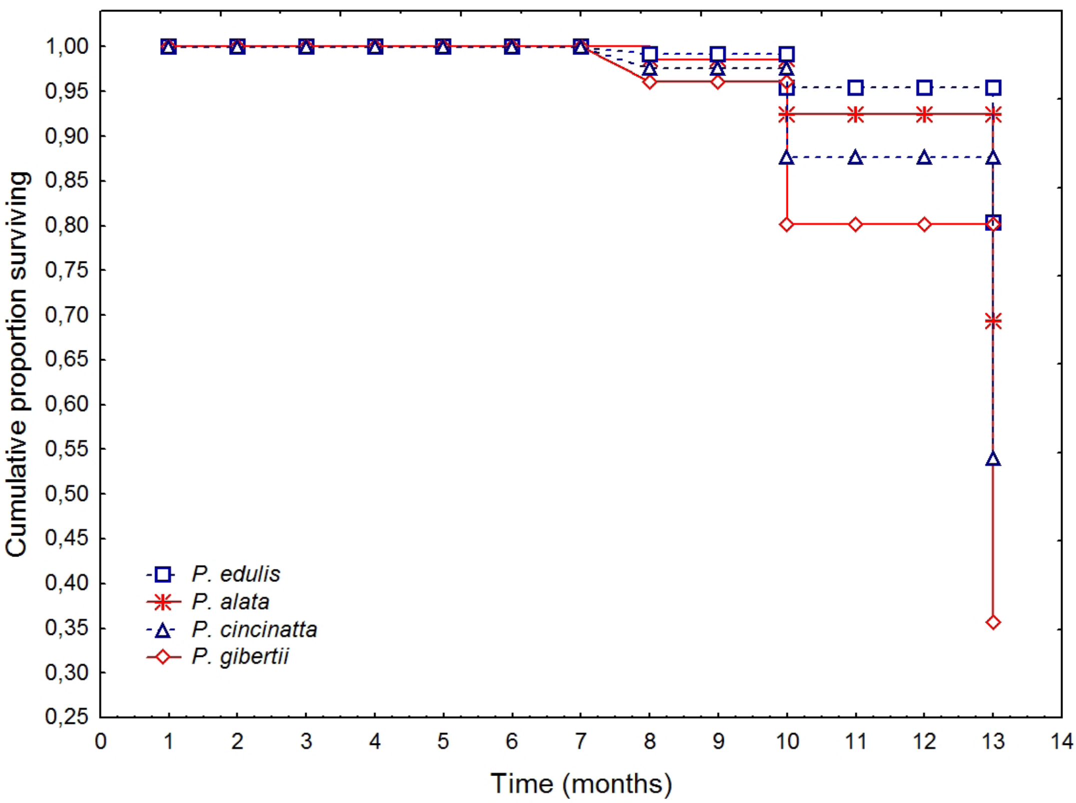

FIGURE 1- Cumulative survival ratio (%) of yellow passion fruit plants (*P. edulis)* symptomatic of fusariosis and grafted on plants of *P. edulis* Sims, *Passiflora alata* Curtis, *P. cincinnata* Mast. and *P. gibertii* N. E., from planting up to 13 months after transplanting. ($P \leq 0.041$).

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