Research, Society and Development, v. 9, n. 8, e849986409, 2020
(CC BY 4.0) | ISSN 2525-3409 | DOI: http://dx.doi.org/10.33448/rsd-v9i8.6409

Produção de mudas de maracujazeiro por enxertia sob porta-enxertos de espécies de passifloras nativas

Production of passion fruit seedlings by grafting using native passiflora species rootstocks

Producción de semillas de frutas de pasión por injerto con titulares gráficos de especies nativas de pasifloro

Recebido: 07/07/2020 | Revisado: 14/07/2020 | Aceito: 17/07/2020 | Publicado: 31/07/2020

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Resumo

Para a obtenção de mudas sadias e plantações mais uniformes de maracujazeiro, o objetivo do presente trabalho é analisar o desenvolvimento de porta enxertos e mudas enxertadas até a época de florada, tendo como tratamentos: *Passifora edulis* não enxertado, e o mesmo enxertado em dois métodos diferentes, sendo eles a enxertia simples, *P. edulis* sobre *P. caerulea* e *P. edulis* sobre *P. giberti*, e a dupla enxertia, *P. edulis* sobre *P. giberti* e *P. caerulea*, na mesma planta, com 3 repetições em 2 blocos. Avaliou-se o poder germinativos das sementes das três espécies utilizadas de acordo com o período de armazenamento, a viabilidade dos métodos de enxertia utilizados, a altura das plantas após o período de juvenilidade e a taxa de crescimento relativo. Observou-se que os tratamentos de maracujá azedo sobre *P. caerulea* obteveram um bom desenvolvimento inicial, reduzindo mais acentuadamente na última coleta de dados que os tratamentos de maracujá sobre *P. giberti* e dupla enxertia, onde os mesmos obtiveram valores iniciais próximos e pequeno decréscimo com o avanço das coletas. Para o maracujá azedo não enxertado houve acúmulo de matéria no início do desenvolvimento das plantas, com sua redução ao longo das coletas, com tendência a estabilização, principalmente se aproximando do florescimento. Verifica-se que as plantas não enxertadas tendem a começar se desenvolver primeiro, conferindo um adiantamento fisiológico, quando comparadas a dupla enxertia ou enxertia simples com *P. caerulea*; e também por causa do vigor do porta enxerto, onde este apresenta baixo potencial. A utilização de *P. giberti* como porta-enxerto parece ser mais viável para a cultura do maracujá.

Palavras chave: *Passiflora ssp;* Propagação vegetative; Vigor de desenvolvimento; Cultivo de plantas nativas.

Abstract

To obtain uniform passion fruit plantations, the aim of this research is to analyze the development of rootstocks and grafted seedlings, using the following treatments: non-grafted *Passifora edulis* and grafted with two different method: single grafting, *P. edulis* on *P. caerulea* and *P. edulis* on *P. giberti*, and double grafting, *P. edulis* on *P. giberti* and *P.*

caerulea, on the same plant, with 3 replicates in 2 blocks. The germinative potential of seeds of the three species used was evaluated according to the storage period, viability of the grafting methods used, plant height after the juvenile period and relative growth rate. It was observed that treatments of passion fruit on *P. caerulea* obtained good initial development, reducing more sharply in the last data collection compared to treatments of passion fruit on *P. giberti* and double grafting. For non-grafted passion fruit, there was matter accumulation at the beginning of plant development, with reduction throughout collections, with tendency to stabilization, mainly approaching flowering. It was verified that non-grafted plants tend to start developing first, showing physiological advance, when compared to double grafting or single grafting with *P. caerulea*, also due to the rootstock vigor, which presents low potential. Using *P. giberti* as a rootstock seems to be more viable for the passion fruit culture.
Keywords: *Passiflora* ssp; Vegetative propagation; Development vigor; Cultivation of native plants.

Resumen

Para obtener plántulas saludables y plantaciones de maracuyá más uniformes, el objetivo del presente trabajo es analizar el desarrollo de portainjertos y plántulas injertadas hasta la temporada de floración, teniendo como tratamientos: Passifora edulis no injertada, y la misma injertada en dos métodos. diferente, siendo el injerto único, *P. edulis* en *P. caerulea* y *P. edulis* en *P. giberti*, y el doble injerto, *P. edulis* en *P. giberti* y *P. caerulea*, en la misma planta, con 3 repeticiones en 2 bloques El poder germinativo de las semillas de las tres especies utilizadas se evaluó de acuerdo con el período de almacenamiento, la viabilidad de los métodos de injerto utilizados, la altura de las plantas después del período de la juventud y la tasa de crecimiento relativa. Se observó que los tratamientos de maracuyá en *P. caerulea* obtuvieron un buen desarrollo inicial, reduciéndose más marcadamente en la última recopilación de datos que los tratamientos de maracuyá en *P. giberti* y doble injerto, donde obtuvieron valores iniciales cercanos y una pequeña disminución con el avance de las colecciones. Para la fruta de la pasión agria no injertada, hubo una acumulación de materia al comienzo del desarrollo de las plantas, con su reducción a lo largo de las colecciones, con una tendencia a estabilizarse, acercándose principalmente a la floración. Se verifica que las plantas no injertadas tienden a comenzar a desarrollarse primero, dando un avance fisiológico, en comparación con el injerto doble o el injerto simple con *P. caerulea*; y también por el vigor del portainjerto, donde tiene un bajo potencial. El uso de *P. giberti* como portainjerto parece ser más viable para el cultivo de maracuyá.

Palabras clave: *Pasiflora* ssp; Propagación vegetativa; Vigor de desarrollo; Cultivo de plantas nativas.

1. Introduction

Passion fruit (*Passiflora* spp.) is a climbing perennial plant belonging to the *Passifloraceae* botanical family, and its largest world production is concentrated in Brazil, Colombia, Ecuador and Peru (Fronza & Hamann, 2015). Annual Brazilian production was 703,489 tons, with area of 49,889 hectares (Anuário Brasileiro De Fruticultura, 2018).

Passion fruit propagation is made from seeds; however, some difficulties arise, generating the need for increased research, since there is unevenness in the production of adult plants and in the germination time (Martins et al., 2010), either by seed dormancy or by residual aryl compounds that surround the seed, presenting substances that affect germination potential, acting as plant regulators (Pereira & Dias, 2000).

For greater uniformity and productivity, the use of rootstocks becomes an interesting alternative (Mahunu et al., 2013), also providing better quality of seedlings by using healthy and vigorous matrices (Roncatto et al., 2008). In addition, it is a more effective, economical and ecological alternative (Salazar et al., 2017) to guarantee and enable the induction of the resistance characteristic to passion fruit through grafting on resistant and healthy plants in relation to the main diseases of the culture, so that the characteristic lasts longer than conventional cultural treatments (Delanöe, 1991; Junqueira et al., 2006).

Thus, the aim of the present work was to analyze, in quantitative parameters, the development of rootstocks and grafted passion fruit seedlings until the flowering period.

2. Methodology

The qualitative and quantitative field experiment (Pereira et al., 2018) was initiated during January 2018, at the School of Agrarian Science and Technology - UNESP / FCAT, Campus of Dracena-SP, whose geographical coordinates are 21 ° 28'57 ″ S and 51 ° 31'58 ″ W and 421 m a.s.l., with subtropical regional climate and average annual temperature of 23.6°C, according to Köeppen (1948), in partnership with the “Alta Paulista” São Paulo Agribusiness Technologies Agency (APTA), located in the municipality of Adamantina - SP.

Passiflora giberti and *Passiflora caerulea* seeds were distributed in expanded polystyrene trays containing Carolina Soil® commercial substrate, according to a randomized block design. Two blocks with 25 replicates each were used, with 3 seeds per experimental plot.

Seeds used were stored in paper bags at room temperature, provided by APTA, with different storage periods, *P. giberti* seeds being stored for 7 years and *P. caerulea* stored for 2 years in order to identify the effect of time on the germination rate.

Fifteen days after sowing, the germination percentage was counted by the number of seedlings in relation to the total sown seeds, and at 20 days, seedlings were transplanted in plastic bags containing sieved soil and conducted in greenhouse until the time of grafting (Cavichioli et al., 2009).

At 90 days after sowing, grafting was carried out using the cleft grafting method, using *P giberti* and *P. caerulea* species as rootstock and traditional *Passiflora edulis* f. as graft, commercially obtained, in a completely randomized design with 10 replicates per treatment, each treatment consisting of non-grafted *P. edulis* f.; *P.edulis* f. grafted on *P. giberti* and *P. edulis* f. grafted on *P. caerulea*. Twenty days after grafting, the fruit set rate was analyzed by means of the number of grafts that healed and kept the grafted bud active.

After grafting setting, 6 seedlings were randomly selected from each grafted treatment to perform a double grafting of *P. edulis* f. on *P. giberti* and *P. caerulea*, by touching the canopy of the first graft, counting their viability 20 days after the procedure.

At 40 days after the last vegetative propagation procedure, all seedlings were carried out on 15 m vertical shoots, with two # 12 galvanized wires with distance of 1.6 m between plants and 2.0 m between rows.

Fertilization was carried out in pits, according to recommendations of Raij et al. (1997), present in bulletin 100 published by IAC (Instituto Agronômico de Campinas) for passion fruit crop and drip irrigation twice a day, with average precipitation of 2.0 mm / h.

Four treatments were used (non-grafted *P.edulis* f., *P. edulis* f. grafted on *P. giberti*, *P. edulis* f. grafted on *P. caerulea* and *P.edulis* f. on *P. giberti* and *P caerulea*), in randomized blocks in a scheme of plots subdivided in time without dependence on factors using seedlings produced by grafting, with 3 plants per treatment, each plant being considered a replicate.

During vegetative development until flowering, plant height (m) and relative growth rate (RGR) were evaluated, considering the increase in the mass of selected branches per unit of original mass, measured by its length, in centimeters, every 10 days, using the following formula used by Benincasa (2003):

$RGR = (\ln R2 - \ln R1) / \Delta T$ where,

R1 = initial branch length;

R2 = final branch length;

ΔT = period, in days, which delimits the beginning and end of measurements of the length of branches.

Data were analyzed using the SISVAR software (Ferreira, 2014). Analysis of variance was carried out and the F test at 5% probability was applied to detect differences between treatments. When significant difference was found for each variable, regression analysis of variance was performed, with model being verified from the p-value of the regression deviation (not significant) and the selected polynomial regression models based on higher determination coefficients (R^2) among significant regressions by the F test.

3. Results and Discussion

It was observed that both species analyzed had different germination percentages, not only by the influence of genotype, but also of the storage time of each seed group, where *P. giberti* seeds presented higher germination percentage than *P. caerulea* seeds, with 61.3% and 43.3%, respectively.

According to Santos et al. (2012), there are wild passiflora species that have seed germination difficulties. According to Morley-Bunker (1974), one of the reasons for this fact is dormancy related to mechanisms that control the entry of water into the seed, and the seed coat thickness is a limiting factor to permeability.

According to Meletti (2002), the ideal seed storage period is one that, in general, enables obtaining germination percentages greater than 95; value that decreases about 8% per month, with continued storage. Thus, in common passion fruit, seeds are usually discarded after six months of harvesting due to the low germination rate, in addition to the occurrence of higher probability of abnormal seedlings.

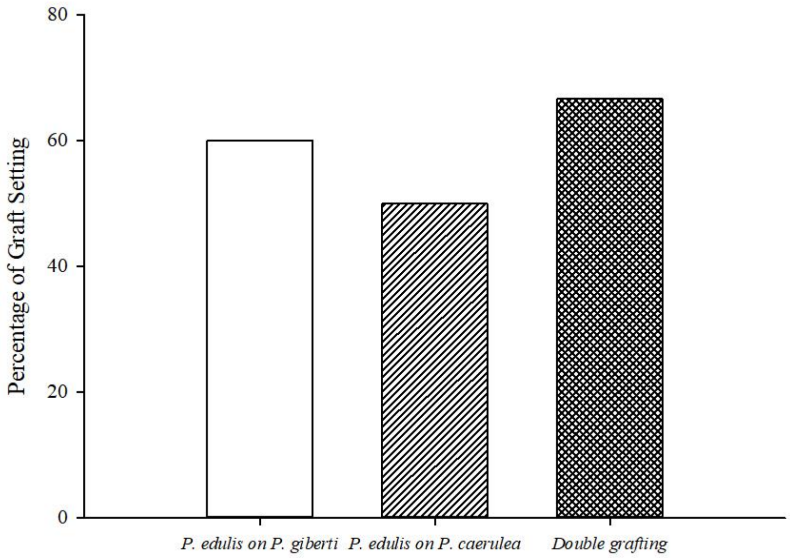
However, in the case of wild species such as *Passiflora setacea*, *P. cincinatta* and *P. nitida*, considered tolerant to diseases and with potential to be used as rootstocks, the dormancy period is much longer, requiring storage period greater than two years to obtain satisfactory germination rates (Meletti, 2002). In *P. alata*, Anselmo (2002) observed the need for a longer storage period of seeds of this species.

Nogueira Filho et al. (2011) found that the germination percentage was comparatively low for *P. gibertii* (32%), *P. cincinnata* (33%), and *P. caerulea* (55%), corroborating results of the present study.

Treatments with different methodologies for seed coat scarifying may be an alternative to reduce the low germination percentage in native *Passiflora* species, as reported by Silva et al. (2008), who used chemical scarification of *P. nitida* seeds and Rossetto et al. (2000), with mechanical scarification of *P. Alata* seeds to increase the seed germination of these species. However, Lima et al. (2012), concluded that none of the these treatments had an effect on the germination of *P. giberti*, for which it will be necessary to test other dormancy breaking methods, in agreement with Passos et al. (2004).

Regarding the viability of the production of seedlings by grafting, it was observed that *P. giberti* (60% of setting) shows better performance compared to *P. caerulea* (50% of setting). For double grafting, the fixation was 66.7%, as can be seen in Figure 1.

Figure 1. Percentage of *Passiflora edulis* Sims graft setting in native passion fruit species. Dracena - SP, 2018.



Source: Authors.

Silva et al., (2018), who found 70% of setting in the grafting of *P. edulis* Sims on *P. giberti*; however, with 100% of setting in the grafting of *P. edulis* Sims on *P. caerulea*, showing greater compatibility of this species.

The difference found in this work suggests that, although both rootstock species exhibit the same season, sowing and grafting characteristics, *P. giberti* showed faster development, which provided more success to grafts performed on this rootstock (Espíndola et al., 2004; Gomes et al., 2010).

These results are in agreement with those obtained by Lima et al. (1997) who evaluated rootstocks and grafting types for passion fruit and found it necessary to sow *P. alata* and *P. caerulea* species 15 days in advance when compared to *P. giberti*, since the latter has higher emergence and germination rates and, consequently, plants obtained are able to graft in shorter time, and may also interfere with the graft fitting uniformity, impairing "peel with peel" healing among passion fruit species (Roncatto et al., 2011).

In a study with pitanga tree propagation, Franzon et al. (2008) found that double graft showed low setting in relation to cleft grafting, justified by the fact that cleft grafting is a faster method, avoiding longer time of exposure of tissues to the environment, and consequently, oxidation of phenolic compounds. However, it is possible to observe that the setting rate of double grafting did not differ statistically from cleft grafting using *P. giberti* rootstock.

Plant growth analysis is a variable widely used to study the physiological bases of production and to highlight the intervention of environmental, genetic and agronomic factors, following the dynamics of photosynthetic production evaluated through the accumulation of plant material, enabling the verification of the adaptability of species in diverse ecosystems (Silva et al., 2000).

Among plant growth and development components, the most used are the relative growth rate of plants and their height at the end of the vegetative growth phase, that is, until the appearance of the first floral bud, indicating the end of the juvenile period, which, in the present study, first occurred in *P. edulis* f. grafted on *P. giberti*, a result similar to Salazar et al. (2017), who obtained *P. edulis* on *P. mucronata* followed by *P. edulis* on *P. giberti* as earlier combination.

At the end of the vegetative development period, according to the analysis of variance by Test F, it was found that there was significant difference for final plant height between the control (not grafted) and the other treatments in which the grafting method was used, as can be seen below in Table 1.

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Table 1. Analysis of variance for plant height (m) of grafted passion fruit. Dracena - SP, (2018).

Source of variation	Mean square
Block	0.0913^{NS}
Treatments (T)	0.8550*
CV (%)	24.00
Treatments	**Means**
Non-grafted *P. edulis*	2.7900 ± 0.1104 A[1]
P. edulis on *P. giberti*	1.9850 ± 0.1854 B
P. edulis on *P. caerulea*	1.9983 ± 0.3050 B
Double grafting	2.2000 ± 0.2171 B
General average	2.2433

** and ^{ns}, significant at 5% and non-significant, respectively, by Test F. [1]Means followed by the same letter do not differ between rows by the Scott-Knott test at 5% probability. Source: Authors.

Thus, it appears that non-grafted passion fruit plants tend to start developing first, showing physiological advance, as the primary plant growth is not interrupted by cutting for grafting, when compared to double grafting or single grafting on *P. giberti* and *P. caerulea*.

Although there is no statistical difference in plant height for the treatment in which the grafting method was used ($p > 0.05$), there was great variation in the relative growth rate calculated using these values.

The relative growth rate (RGR) considers the increase in the dry organic matter of a plant in a determined period of time, depending on its initial size (Benincasa, 2003). For Briggs et al. (1920), as it is dependent on the amount of material that is being accumulated, it is considered the most appropriate methodology to evaluate plant development, which is of great importance to understand the morphophysiological processes of plants aiming at improving the crop.

The graphs representing the relative growth rate of passion fruit plants, according to each treatment, are shown below, in Figure 2.

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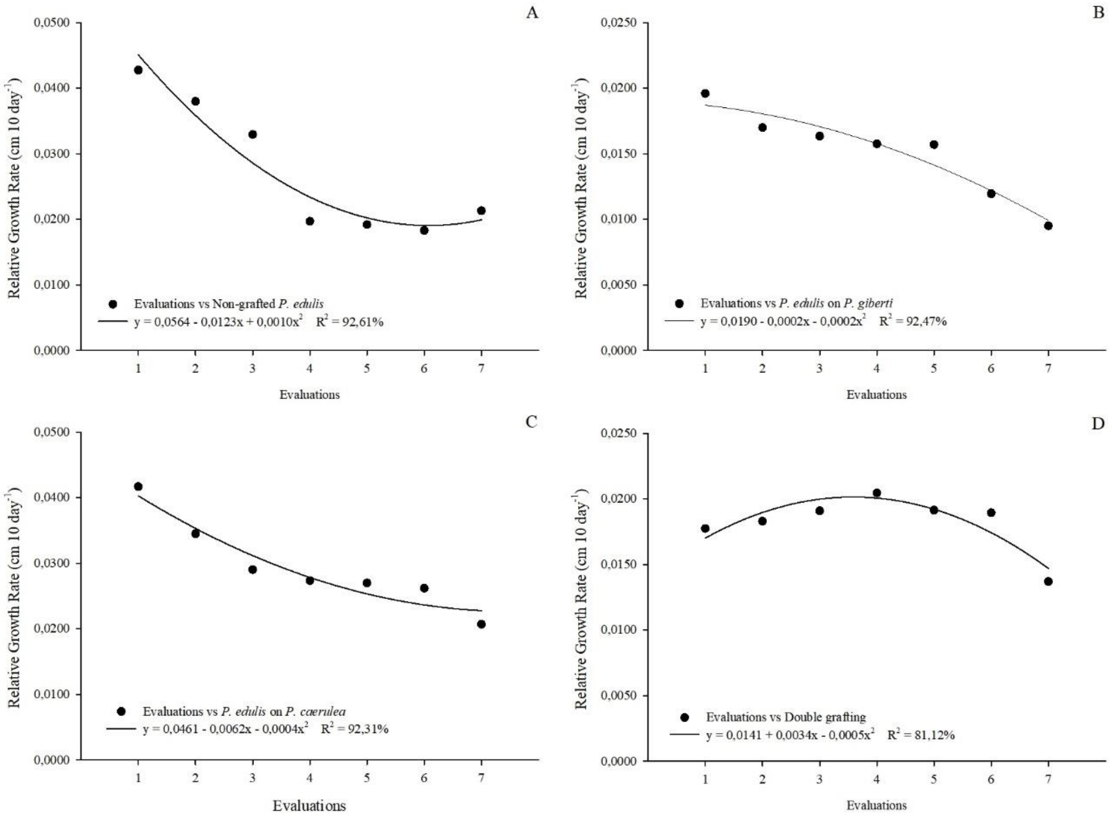
Figure 2. Relative Growth Rate of passion fruit plants. Non-grafted *P. edulis* (A); *P. edulis* on *P. giberti* (B); *P. edulis* on *P. caerulea* (C); Double grafting (D). Dracena - SP, 2018.



Source: Authors.

It was observed that the only treatment that followed the pattern of matter accumulation at the beginning of plant growth, with reduction throughout its development was non-grafted *P. edulis* f., which can be seen in Figure 2-A. *P. edulis* f. grafted on *P. giberti* presented similar pattern of this parameter, but with a delay in its stabilization due to the grafting process (Figure 2-B).

This fact can be explained, in addition to the increase in respiratory activity, by the increase in self-shading with plant development (Barreiro et al., 2006). In addition, according to Ferrari et al. (2008), the decrease in RGR over the flowering plant cycle is expected, since with the beginning of flowering, the need for photoassimilates for the maintenance of reproductive structures increases, decreasing the amount available for growth.

Figures 2-C and 2-D show the growth rate of *P. edulis* f. grafted on *P. caerulea*, *P. edulis* f. grafted on *P. giberti P. caerulea*, without double grafting system, respectively.

Regarding the RGR of *P. edulis* f. grafted on *P. caerulea*, it was observed that, from the third collection, there is a tendency for these plants to follow the pattern of rapid material accumulation at the beginning of development, followed by a decrease along their growth, showing a delay in their normal development, tending to stabilization.

In contrast, the RGR of plants with double grafting does not show any pattern of growth and development, as previously observed, justified by the fact that double grafting affects plant growth twice (Franzon et al., 2008) compared with single grafting, reallocating the use of plant energy for the healing of the cut site.

According to Cavichioli et al. (2009), after the first grafting, after healing, the remaining energy for the maintenance of plant tissues is destined for vegetative growth; however, in this case, this process is interrupted by the second grafting.

4. Final Considerations

The use of grafting technique for the production of passion fruit seedlings is a promising alternative, mainly with the use of native species, considered to be resistant to the main diseases of the crop, however, the low canopy vigor rendered by the use of this methodology still needs to be resolved, aiming to make it feasible so that appropriate handling is recommended.

Regarding the two native species in question, the option of using *P. giberti* as a rootstock seems to be more viable for the passion fruit culture.

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