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GRAFTING SUCESS IN DIFFERENT COMBINATIONS OF SPECIES AND VARIETIES USED AS SCION AND ROOTSTOCK OF PASSION FRUIT PLANT

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ABSTRACT

This research aimed to evaluate the success of grafting in combinations of scion varieties and species of rootstocks of passion fruit plant. The study was conducted in screenhouse at Acre Embrapa, in Rio Branco, from December in 2012. The scion variety used for all treatments was the yellow passion fruit 'FB 100' and 'FB 200' from Flora Brazil nursery (Araguari, MG) and 5 other regional varieties (UFAC, Universidade Federal do Acre, Rio Branco-AC). The rootstocks used were *Passiflora edulis* (yellow passion fruit) (Cuiabá-MT), *P. alata, P. edulis* (purple passion fruit) and *P. quadrangularis* (Guiratinga-MT), *P. serrato-digitata* (IAC-Campinas/SP). The grafting method used was the cleft graft at the hypocotyl top, with rootstocks having the following characteristics: three true leaves and varying seedling heights, 30 to 90 days after sowing. The combination of better performance in relation to graft taking was UFAC 07 on *P. edulis* (purple passion fruit plant) and *P. alata*, UFAC 38 on *P. edulis* (yellow passion fruit plant), *P. edulis* (purple passion fruit plant) and *P. alata*, UFAC 64 on *P. serrato-digitata*, achieving a 100% graft take, while the combination of FB 100 on *P. alata* had the worst performance, with low rate of success, not reaching 30%.

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INTRODUCTION

The passion fruit plant is a typical crop of tropical countries, and Brazil is responsible for about 90% of global production (Silva *et al*., 2005). Brazil is the largest producer of passion fruit, producing 684,000 tons of fruit (IBGE, 2024). The largest producers are the states of Bahia, São Paulo, Sergipe, Espírito Santo, Pará, Ceará, and Minas Gerais, which represent for 80% of national production, with Bahia alone representing 40% of production with 275,000 tons of fruit. The national average productivity is low, at about 13 t/ha/year. The state of Acre has one of the lowest productivity of passion fruit, representing only 0.1% of Brazilian production, with a productivity of 6 t/ha/year, being necessary to import it from other producing regions (IBGE, 2024). The low production and productivity of passion fruit plant in the state of Acre, as well as the lower fruit quality, are caused by many factors, mainly by the lack of adapted technologies for the region. And, concerning to the yellow passion fruit, the most used method is by seed propagation, which has several limitations, such as low productivity, small fruits, uneven orchards, with both productive and unproductive plants, and susceptibility to pests and diseases. More appropriate new technologies need to be developed, and alternative methods must be offered to producers for exploiting the potential of the crop. One of such method is grafting, which provides the possibility of propagating plants of native species that are resistant or tolerant to drought, pests, nematodes, and diseases, such as fusariosis (Fusarium oxysporum Schlecht. f. passiflorae Purss.), preventing premature plant death.

The last one consists of the sudden wilting of the plant due to crown rot, which interrupts the flow of sap and leads to reduced crop longevity and the abandonment of areas with high inoculum levels. Thus, preserving these resistance traits allows the use of resistant or tolerant species as rootstocks of yellow passion fruit, resulting in healthy crops (Delanöe, 1991; Junqueira *et al*., 2006). Another important aspect is plant cloning, as the conventional seed propagation method that transmits a low percentage of desirable agronomic traits from the progenitors, whether it is productivity, fruit quality, or resistance to pests and diseases, due to the segregation of traits inherent in the method. Grafting allows for the faithful transmission of characteristics offered by the parent plants, enabling the formation of homogeneous, productive, and early-bearing orchards (Lima *et al*., 1994). In general, the results obtained regarding to grafting adhesion found in the literature are contradictory (Corrêa, 1978; Oliveira *et al*., 1983; Pace, 1983; Seixas *et al*., 1987; Baccarin, 1988; Menezes, 1990; Staveley & Wolstenholme, 1990; Stenzel & Carvalho, 1992; Menezes *et al*., 1994; Kimura, 1994; Lima *et al*., 1997; Lima *et al*., 1999; Lima, 1999; Chaves *et al*., 2004). It is important to highlight the variation in methods, rootstocks, and even grafts found in this literature, indicating the need for new studies. A significant variation in grafting adhesion is also reported in the literature, even when the same grafting method and the same graft/rootstock combination are used. Therefore, the aim of this study was to evaluate grafting adhesion in combinations of scion varieties and rootstock species of passion fruit plant.

MATERIALS AND METHODS

The study was conducted at the experimental nursery of Embrapa Acre, in Rio Branco, AC, from September to December 2012. The municipality is located at 10º1'S and 67º42'W, at an altitude of 160 m. The climate is classified as AWI (hot and humid) according to Köppen, with a maximum temperature of 30.92ºC, a minimum temperature of 20.84ºC, annual precipitation of 1,648.94 mm, and relative humidity of 83% (Agritempo, 2008). The experimental nursery is covered with black shade cloth, providing 50% shading for the passion fruit seedlings. The micro-sprinkler irrigation system allowed for daily overhead watering, as the seedling trays with grafted plants were suspended about 0.5 m above the ground on masonry benches. So, this aeration led to root pruning that extended beyond the container, preventing roots from touching the ground and hindering seedling development. Two sowings were conducted to obtain the rootstocks. In the first (03-09-2012), 100 seeds of each rootstock were used without any prior treatment. In the second (04-10-2012), 120 seeds of each rootstock were soaked in distilled water for about twelve hours before being sown in polyethylene tubes with commercial Plantmax substrate. In the same way, yellow passion fruit seedlings were produced to supply of the grafts, sowing 100 seeds in tubes for seven weeks. When the rootstocks and scions reached the grafting stage (October/November 2012), measuring about 6 to 8 cm in height with three true leaves—achieved 30 days post-sowing for the faster-growing species and 90 days for the slower-growing ones—grafting was performed. The grafting method used was cleft grafting at the hypocotyl top.

Table 1. Genotypic Value (VG), Lower Limit of Confidence Interval (LLCI), and Upper Limit of Confidence Interval (ULCI) of grafting success percentage for combinations of scion varieties and rootstock species of passion fruit, 30 days after grafting, in the experimental nursery of Embrapa Acre, Rio Branco-AC.

Order	Treatment	Scion/Rootstock	VG	LLCI	ULCI
1	12	UFAC 07/P. edulis (purple passion fruit)	99.0273	90.1966	107.8581
2	14	UFAC 07/P. alata	99.0273	90.1966	107.8581
3	21	UFAC 38/P. edulis (yellow passion fruit)	99.0273	90.1966	107.8581
4	22	UFAC 38/P. edulis (purple passion fruit)	99.0273	90.1966	107.8581
5	24	UFAC 38/P. alata	99.0273	90.1966	107.8581
6	33	UFAC 64/P. serrato-digitata	99.0273	90.1966	107.8581
7	2	FB 100/P. edulis (purple passion fruit)	97.0626	88.2318	105.8934
8	6	FB 200/P. edulis (yellow passion fruit)	97.0626	88.2318	105.8934
9	16	UFAC 70/P. edulis (yellow passion fruit)	97.0626	88.2318	105.8934
10	31	UFAC 64/P. edulis (yellow passion fruit)	97.0626	88.2318	105.8934
11	11	UFAC 07/P. edulis (yellow passion fruit)	95.0979	86.2671	103.9287
12	17	UFAC 70/P. edulis (purple passion fruit)	95.0979	86.2671	103.9287
13	26	UFAC 25/P. edulis (yellow passion fruit)	95.0979	86.2671	103.9287
14	7	FB 200/P. edulis (purple passion fruit)	93.1332	84.3024	101.964
15	28	UFAC 25/P. serrato-digitata	93.1332	84.3024	101.964
16	13	UFAC 07/P. serrato-digitata	91.1685	82.3377	99.9992
17	29	UFAC 25/P. alata	89.2038	80.373	98.0345
18	32	UFAC 64/P. edulis (purple passion fruit)	89.2038	80.373	98.0345
19	1	FB 100/P. edulis (yellow passion fruit)	87.239	78.4083	96.0698
20	18	UFAC 70/P. serrato-digitata	87.239	78.4083	96.0698
21	23	UFAC 38/P. serrato-digitata	87.239	78.4083	96.0698
22	27	UFAC 35/P. edulis (purple passion fruit)	85.2743	76.4436	94.1051
23	8	FB 200/P. serrato-digitata	83.3096	74.4788	92.1404
24	25	UFAC 38/P. quadrangularis	83.3096	74.4788	92.1404
25	3	FB 100/P. serrato-digitata	77.4155	68.5847	86.2462
26	9	FB 200/P. alata	77.4155	68.5847	86.2462
27	19	UFAC 70/P. serrato-digitata	77.4155	68.5847	86.2462
28	34	UFAC 64/P. alata	71.5213	62.6906	80.3521
29	5	FB 100/P. quadrangularis	69.5566	60.7258	78.3874
30	10	FB 200/P. quadrangularis	63.6625	54.8317	72.4932
31	30	UFAC 25/P. quadrangularis	55.8036	46.9728	64.6344
32	20	UFAC 70/P. quadrangularis	53.8389	45.0081	62.6696
33	15	UFAC 07/P. quadrangularis	45.98	37.1493	54.8108
34	35	UFAC 64/P. quadrangularis	44.0153	35.1845	52.8461
35	4	FB 100/P. alata	28.2976	19.4668	37.1283

The scion varieties used for all treatments were the yellow passion fruit 'FB 100' and 'FB 200' (Flora Brasil 100 e 200) from the Flora Brasil nursery (Araguari, MG). These selections were developed from a mixture of various genotypes in the Araguari region, with the goal of producing fruit for the industry, although they are also consumed fresh due to their characteristics, their uniform size, shape, and color (average weight of 240g), thicker skin for better transport resistance, pulp yield around 36%, and 14.0ºBrix, with a production potential of 50 t/ha/year. Five other regional varieties (UFAC - Federal University of Acre, Rio Branco - AC) were also used as scions and are still being evaluated for their productive characteristics and fruit quality. The rootstocks used were Passiflora edulis (yellow passion fruit) (Cuiabá-MT access), P. alata, P. edulis (purple passion fruit), P. quadrangularis (Guiratinga-MT access), and P. serrato-digitata (IAC-Campinas/SP access). The rootstock was decapitated at the cotyledons, and a longitudinal split (1.0 cm) was made. After removing the graft, also decapitated below the cotyledons to expose the crown region, a double bevel wedge was cut, exposing the cambial tissues with a platinum blade. The graft and rootstock were then carefully joined to align the cambial tissues, using adhesive tape (crepe) to wrap the graft area, protecting it from drying out and excess moisture while also serving as a support for the seedling. Immediately after grafting, the grafted seedling, placed in tube trays, was supported by a wooden stake (25 cm) and protected with a transparent plastic bag (4 x 23 cm) to create a humid chamber. After 20 days, the plastic bag was removed. The substrate used was a mix of soil, well-rotted manure, and vermiculite (3:1:1, v), packed in black polyethylene tubes measuring 25 x 5 cm or 288 cm^3. The experimental design was a randomized block with six replications. The treatments consisted of 35 scion/rootstock combinations (combination of 5 rootstocks x 7 scions). Each plot was consisted of eight plants, with no border.

At this stage, grafting success was assessed by the percentage of grafted seedlings that succeeded 30 days after grafting in each individual. Genetic parameters were estimated using the Restricted Maximum Likelihood (REML) method, and genotypic values were

predicted using Best Linear Unbiased Prediction (BLUP) based on mixed model methodology (Henderson, 1984), utilizing the Selegen software (Rezende, 2002). The following statistical model was considered: y = Xm + Zg + Wp + Ts + e, where y is the data vector, m is the vector of the effects of the measurement-replication combinations (assumed as fixed) added to the overall mean, g is the vector of genotypic effects (assumed as random), p is the vector of plot effects (random), s is the vector of permanent environmental effects (random), and e is the vector of errors or residuals (random). The capital letters represent the incidence matrices for the respective effects. The vector m encompasses all measurements across all replications, and adjusts simultaneously for the effects of replications, measurements, and the interaction of replication x measurement.

RESULTS E DISCUSSIONS

The grafting success rates were excellent for certain scion/rootstock combinations, reaching 100% success, such as the combination of P. edulis (purple passion fruit) as rootstock with UFAC 07 (Table 1). It is noteworthy that in most of the species and varieties used, the grafting success exceeded 80%. However, in other combinations, the success was below expectations, such as P. alata with FB 100, which had less than 30% success (the lowest value compared to the others).
In Table 1, it also shows that the combinations with the best grafting performance were UFAC 07 on P. edulis (purple passion fruit) and P. alata, UFAC 38 on P. edulis (yellow passion fruit), P. edulis (purple passion fruit), and P. alata, and UFAC 64 on P. serrato-digitata. These achieved 100% grafting success, demonstrating a perfect relationship between the scion varieties and the rootstock species involved, resulting in excellent performance. The genotypic value (VG), which isolates the environmental factor, was 99.0230 for these genotypes, with a Lower Confidence Interval Limit (LCI) of 90.1966 and an Upper Confidence Interval Limit (UCI) of 107.8581. It can also be observed that the combinations FB 100 on P. edulis (purple passion fruit), FB 200 on P. edulis (yellow passion fruit) and P. edulis (purple passion fruit), UFAC 70 on P. edulis (yellow passion fruit) and P. edulis (purple passion fruit), UFAC 07 on P. edulis (yellow passion fruit) and P. serrato-digitata, UFAC 25 on P. edulis (yellow passion fruit) and P. serrato-digitata, and UFAC 64 on P. edulis (yellow passion fruit) were not different from the previously mentioned combinations, placing them in the same group. This is evidenced by the VG of 91.1685 for the combination UFAC 07 on P. serrato-digitata (lower limit of the group) when compared to the previously mentioned LCII, positioning it above the other passion fruit combinations.

These results are consistent with those obtained by Nogueira Filho (2003) and Nogueira Filho *et al*. (2005), who achieved similar results with the combinations of FB 200 on P. edulis (yellow passion fruit) and P. alata. Also, Menezes (1990) and Menezes *et al*. (1994) achieved excellent grafting success using those previously mentioned rootstock combinations. Chaves *et al*. (2004), Silva *et al*. (2005), and Junqueira *et al*. (2006) also reported high performance with the mentioned rootstocks derived from cuttings. However, Lenza *et al*. (2009) achieved excellent grafting success using P. edulis (purple passion fruit) and P. quadrangularis, which was also observed in the present study. This success may be related to an optimal union at the grafting point, resulting from the uniformity of the material in terms of diameter and lignification of the graft and rootstock tissues. In other words, the diameter and lignification of both plant materials are similar, allowing an excellent union and fusion of the tissues. It should be considered that the hypocotyl grafting type minimized the differences in stem diameter and lignification of the tissues present in adult plants of those species and varieties. This occurred because seedlings were used for this type of grafting. At the seedling stage, the characteristics of diameter inconsistency and lignification of the tissues have not yet manifested, favoring the union of the individuals and the fusion of the tissues at the grafting region. Additionally, the isoporous stem characteristic present in adult plant grafts has not yet manifested at the seedling stage, which may have facilitated the union of the tissues. Table 1 also shows that most combinations of scion varieties and rootstock species achieved grafting success rates exceeding 80%, as represented by the VG of 83.3096 for the combination UFAC 38 on P. quadrangularis, which is positioned at the lower limit of the group of combinations, with success greater than the others (83% grafting success when the environmental factor is not isolated), demonstrating that overall, the grafting of scion varieties with rootstock species was very good. However, the combination FB 100 on P. alata had the worst performance, with a low grafting success rate of less than 30%. This is likely due to the lignification of the tissues in the rootstock species and the scion varieties used in this combination, they are not uniform, even though care was taken to select similar diameters of both parts at the time of grafting, with the isoporous stem characteristic that has not yet manifested. This characteristic of lignification in plant tissues is decisive in the outcome. This indicates that not all species and varieties have compatibility with the grafting technique.

CONCLUSIONS

The combinations with the best grafting success were UFAC 07 on P. edulis (purple passion fruit) and P. alata, UFAC 38 on P. edulis (yellow passion fruit), P. edulis (purple passion fruit), and P. alata, and UFAC 64 on P. serrato-digitata, all achieving 100% grafting success. The combination of FB 100 on P. alata had the worst performance, with a low grafting success not achieving 30%. Most combinations exceeded 80% success.

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