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CROP PRODUCTION

Scion-rootstock combinations for orange trees in the state of Amazonas

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ABSTRACT: In the state of Amazonas, the 'Pêra' orange scion is traditionally cultivated on 'Rangpur' lime tree. The restricted use of a single scion-rootstock combination has left local orchards vulnerable to adverse conditions and incidence of pests and diseases, which may negatively interfere with both productivity and fruit quality and the citrus activity sustainability in the state. The expansion of the number of scion-rootstock combinations becomes a viable alternative to overcome such problems. To meet this demand from citrus growers, 30 combinations with 10 scions and 3 rootstocks were evaluated in the sixth and seventh year after planting seedlings in the field in the municipality of Rio Preto da Eva, AM. In this experiment, productivity, juice yield, soluble solids, pH, titratable acidity, ratio and technological index were evaluated. 'Pineapple' scion with 'Sunki Tropical' and 'BRS Bravo' rootstocks can be productive alternatives in relation to traditional 'Pêra' orange scion under 'Rangpur' lime combination in the state of Amazonas. 'Lima' orange with 'Sunki Tropical' mandarin, 'Rangpur lime SC' and 'BRS Bravo' lime rootstocks can be alternatives for the fresh market in the state. Combinations that showed good fruit quality are 'Pêra', 'Salustiana', 'Valência Tuxpan' and 'Westin' scions with 'BRS Bravo' rootstock, and 'Pêra D6' scion with 'Rangpur lime SC' lemon rootstock. These combinations are alternatives for the diversification of orchards in the state of Amazonas.
Key words: *Citrus* × *sinensis* (L.) Osbeck, sweet orange, citrus growing, orchard diversification.

Combinações copa-porta-enxerto para laranjeiras no estado do Amazonas

RESUMO: No estado do Amazonas cultiva-se, tradicionalmente, a laranjeira 'Pêra' sobre o limoeiro 'Cravo'. O uso restrito de uma única combinação de copa-porta-enxerto tem deixado os pomares locais vulneráveis à condições adversas e a incidência de pragas e doenças, podendo interferir negativamente tanto na produtividade como na qualidade dos frutos e sustentabilidade citrícola do Estado. A ampliação do número de combinações-copas-porta-enxertos torna-se uma alternativa viável para superar tais problemas. Para atender a esta demanda dos produtores de citros foram avaliadas 30 combinações com 10 copas e três porta-enxertos no sexto e sétimo ano após o plantio das mudas no campo, no município de Rio Preto da Eva, AM. Nesse experimento foram avaliadas: a produtividade, o rendimento de suco, os sólidos solúveis, o pH, a acidez titulável, o ratio e o índice tecnológico. A copa 'Pineapple' com os porta-enxertos tangerineira 'Sunki Tropical' e 'BRS Bravo' podem ser alternativas produtivas em relação a tradicional combinação laranja 'Pêra' sob limoeiro 'Cravo' no Amazonas. A copa laranja 'Lima' com os porta-enxertos tangerineira 'Sunki Tropical', limoeiro 'Cravo Santa Cruz' e 'BRS Bravo' podem ser alternativas para o mercado *in natura* no estado. As combinações que apresentaram boa qualidade do fruto são as copas 'Pêra', 'Salustiana', 'Valência Tuxpan' e 'Westin' com o porta-enxerto 'BRS Bravo', e a copa 'Pêra D6' com o porta-enxerto limoeiro 'Cravo Santa Cruz'. Estas combinações são alternativas para a diversificação dos pomares do estado do Amazonas.
Palavras-chave: *Citrus* × *sinensis* (L.) Osbeck, laranja doce, citricultura, diversificação do pomar.

INTRODUCTION

Brazil is the world's largest orange producer, and accounts for three quarters of global orange juice exports (USDA-FAS, 2024). Most of the country's production comes from the state of São Paulo and the western part of Minas Gerais, however, other states also produce oranges on a smaller scale (FUNDECITRUS, 2024; IBGE, 2024a).

In the state of Amazonas, orange plantations intensified due to the favorable climatic conditions in the region, combined with the commercial value of the fruit in the market (SILVA et al., 2002). The state has more than 2,400 citrus growers with total planted area of more than 5,000 ha, who cultivate 'Pêra' orange trees on 'Rangpur' lime trees (IDAM, 2019). Production is concentrated mainly in the municipality of Rio Preto da Eva, which is the largest producer in the state, with 70% of production (IBGE, 2024b).

By using only one scion-rootstock combination, orchards are vulnerable to adverse conditions and the incidence of pests and diseases

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(SOUZA et al., 2018). Furthermore, the 'Pêra' orange scion with 'Rangpur' lime rootstock combination used in the region is susceptible to sudden citrus death (POMPEU JUNIOR & BLUMER, 2008). 'Rangpur' lime has already been shown to be susceptible to gummosis (CAIXETA et al., 2013), in addition to being susceptible to citrus decline. Thus, the restricted use of scion-rootstock combinations in a diseased orchard reduces productivity, fruit quality, increases costs with cultural treatments and reduces the useful life of the orchard (POMPEU JUNIOR et al., 2002).

The diversification of orchards can be an alternative to overcome such problems. Therefore, in several regions of the country, new orange cultivars are under study to identify desirable agronomic characteristics such as productivity and fruit quality (BASTOS et al., 2014). Rootstocks can influence tree size, yield, production efficiency, and fruit quality (KUNWAR et al., 2023). Furthermore, rootstocks can also alter specific metabolites, and thus affect the orange juice quality (LIU et al., 2023). Rootstocks have also been shown to interfere with the health of the scion and to be tolerant to diseases (BOWMAN et al., 2023), being also tolerant even under unfavorable soil conditions (CHAUDHRY et al., 2023).

Therefore, the evaluation of new orange tree scions in the state of Amazonas allows selecting more productive and adapted combinations for the state. Combinations that express desirable agronomic characteristics can contribute to the citrus production sustainability in the state, reflecting throughout the production chain. Thus, this research evaluated 30 scion-rootstock combinations for orange trees in the municipality of Rio Preto da Eva, Amazonas.

MATERIALS AND METHODS

The experiment was installed in the municipality of Rio Preto da Eva Amazonas, latitude 02º 42' 24.1" S, longitude 59º 26' 02.6" W and altitude of 80 m above sea level.

The plant material used in the study comes from the germplasm bank of "Embrapa Mandioca e Fruticultura". From available seeds and buds, seedlings were produced by nurseryman accredited by the Ministry of Agriculture, Livestock and Supply – MAPA. Orange scion varieties used were: 'Cara Cara', 'Diva', 'Lima' (Sukari), 'Pera' orange (variety used in the state), 'Pera CNPMF D6', 'Pineapple', 'Rubi', 'Salustiana', 'Valencia Tuxpan' and 'Westin'. Citrus rootstocks used were the ''Rangpur lime SC', 'Sunki Tropical' tangerine and 'BRS Bravo' hybrid.

Seedlings were planted in pits measuring 0.40 x 0.40 x 0.40 m, with dense spacing of 6 m between rows and 2.5 m between plants.

Between orchard lines, as cover plant, Arachis pintoi Krapov. & W.C.Greg legume was established.

Planting fertilization, based on sampling and subsequent soil analysis, consisted of 330 g of simple superphosphate, 5 L of poultry manure and 50 g of FTE Br12. Every year, soil analyses and correction fertilization are carried out whenever necessary.

The experimental design used was in randomized blocks (RBD), with experimental arrangement consisting of 30 treatments and three replicates. The experimental plot consisted of four orange trees of each scion-rootstock combination.

Production was evaluated during the sixth and seventh year of plants in the field. Ripe fruits were manually harvested from each plot of four plants, counted, weighed and packed in harvest boxes. A random sample of fifteen oranges was collected from each plot for physical and chemical analyses.

Average production was calculated by production divided by the number of plants per plot. Average productivity (t ha^{-1}) was calculated by (production in kg/plot x 667), where 667 is the value of 1 hectare divided by the multiplication of spacings.

The 15 fruits were washed, cut in half and the juice was extracted with industrial extractor machine. The juice volume was measured in beaker. Juice yield was calculated using the following relationship [RS = (VS/PF) x 100], where VS = juice volume (mL) and PF = fruit weight (g), expressed as percentage.

Soluble solids were determined by optical refractometer instrument. The methodology used was described in Oliveira (2010a). The pH was determined with previously calibrated pH meter and operated according to instructions in the manufacturer's manual. The acid content of sample was determined according to INSTITUTO ADOLFO LUTZ (2008) methodology with modifications by Oliveira (2010a). Ratio was calculated by the arithmetic relationship between soluble solids (Brix (%) and titratable acidity (SS/AT). The technological index was calculated by the formula, IT = (RS x SS x 40.8) /10,000 -1, where: RS = juice yield, SS = soluble solids content and 40.8 = standard fruit harvest box weight, expressed in kg of soluble solids per box (kg SS box^{-1}) (TAZIMA et al., 2008).

Data with non-normal distribution were transformed by the equation ($\sqrt{x} + 0.5$). Productivity data were submitted to analysis of variance and means

compared by the Scott & Knott test at 5% ($P \leq 0.05$) probability (GOMES, 1976).

Variables i. titratable acidity, ii. technological index, iii. juice yield, iv. soluble solids, v. pH, ix. ratio, were submitted to multivariate analysis. First, they were submitted to principal component analysis (PCA), with correlation circle (95% confidence ellipse).

RESULTS AND DISCUSSION

'Pêra', 'Valência Tuxpan', 'Pineapple', 'Lima' and 'Pêra D6' orange scions had higher productivity with the 'Sunki Tropical' tangerine rootstock in 2019 (Table 1). In the following year, with the same rootstock, 'Pineapple' and 'Lima' orange scions had higher productivity (Table 1). With 'Rangpur lime SC' lime rootstock, 'Valencia Tuxpan', 'Pineapple', 'Lima' orange scions had higher productivity in 2019 (Table 1). In the following year, the 'Pineapple' and 'Lima' orange scions showed higher productivity (Table 1). In relation to the other scions, only 'Pineapple' and 'Lima' orange maintain good productivity in the two years with the two rootstocks. In regions of northeastern Brazil, the 'Pineapple' scion has already shown greater productivity when grafted onto these rootstocks (MARTINS et al., 2020). 'Sunki Tropical' mandarin and 'Rangpur lime SC' lime rootstocks have already shown great potential for diversification of orchards in northeastern Brazil (RIBEIRO et al., 2021).

'BRS Bravo' rootstock with 'Valencia Tuxpan', 'Pineapple' and 'Lima' orange scions had higher productivity in 2019 (Table 1). In the following year, 'Pineapple' and 'Lima' orange scions had higher productivity (Table 1). Again 'Pineapple' and 'Lima' orange scions maintain good productivity in both years. 'BRS Bravo' rootstock has advantages over the other rootstocks, as it induces the formation of a smaller orange tree with high productive efficiency in the first years (CARVALHO et al., 2016). In addition, 'BRS Bravo' rootstock has already proven to be productive in the initial years and adapted to the Amazonian conditions (SANTOS et al., 2021).

'Pêra', 'Pineapple', 'Lima', 'Westin' and 'Pêra D6' orange scions with the three rootstocks, had similar yields in 2019, when considering the influence of the rootstock (Table 1). In the following year, the productivity of 'Pêra', 'Salustiana', 'Valência Tuxpan', 'Diva', 'Cara Cara' and 'Pêra D6' orange scions with the three rootstocks were similar (Table 1). Thus, 'Pêra' and 'Pêra D6' orange scions demonstrated that rootstocks did not influence productivity in the two years evaluated, unlike the other scions that showed influence in one of the years. However, the ''Pêra" scion has already been shown to be influenced by different rootstocks (CARVALHO et al., 2022). Likewise, the 'Pêra D6' scion has already been shown to be influenced by other rootstocks (CARVALHO et al., 2021).

The productivity of 'Salustiana', 'Rubi', 'Valência Tuxpan' and 'Diva' scions were higher with 'Rangpur lime SC' and 'BRS Bravo' lime rootstocks in 2019 (Table 1). In the same year, the ''Cara Cara'' scion had higher productivity with 'BRS Bravo' rootstock (Table 1). The 'Westin' scion had higher productivity with 'BRS Bravo' rootstock in 2020 (Table 1). In the same year, 'Pineapple' and 'Lima' orange scion had higher productivity with

Table 1 - Scion/rootstock interaction regarding productivity (t ha^{-1}) of sweet orange scion within each rootstock. Rio Preto da Eva, AM, 2019-2020. (1)

		Orange varieties									
	Rootstocks	Pera	Salustiana	Rubi	Valencia Tuxpan	Diva	Pineapple	Lima Orange	Westin	Cara Cara	Pera D6
2019	Sunki Tropical	22.3 Aa	0.0 Bb	2.3 Bb	18.6 Ab	0.0 Bb	32.3 Aa	33.1 Aa	0.3 Ba	7.7 Bb	17.5 Aa
	Rangpur lime SC	12.8 Ba	19.4 Ba	21.6 Ba	58.6 Aa	14.8 Ba	29.7 Aa	49.8 Aa	5.2 Ba	20.1 Bb	13.8 Ba
	BRS Bravo	20.2 Ba	19.4 Ba	19.7 Ba	36.9 Aa	25.8 Ba	31.5 Aa	47.8 Aa	6.3 Ba	20.1 Ba	22.8 Ba
	Mean	18.4	12.9	14.5	38.0	13.5	31.2	43.6	3.9	16.0	18.0
	CV (%)	27.46									
2020	Sunki Tropical	6.5 Ba	0.4 Ba	4.7 Bb	1.5 Ba	1.3 Ba	42.5 Aa	46.4 Aa	0.4 Bb	0.4 Ba	2.8 Ba
	Rangpur lime SC	4.8 Ba	2.5 Ba	0.4 Bb	3.3 Ba	0.4 Ba	11.0 Ab	16.7 Ab	0.4 Bb	0.4 Ba	1.2 Ba
	BRS Bravo	8.6 Ba	4.1 Ba	10.0 Ba	4.8 Ba	0.4 Ba	43.2 Aa	36.7 Aa	9.2 Ba	4.5 Ba	5.5 Ba
	Mean	6.6	2.3	5.0	3.2	0.7	32.2	33.3	3.3	1.8	3.2
	CV (%)	31.72									

'Sunki Tropical' and 'BRS Bravo' rootstocks, while the 'Rubi' scion had higher productivity with 'BRS Bravo' rootstock (Table 1). Thus, these combinations showed influence of rootstocks on productivity.

In the state of Amazonas in the last ten years, the average orange productivity was between 10 and 20 t ha^{-1} (IBGE, 2023). 'Pineapple' and 'Lima' Orange with 'Sunki Tropical' mandarin and 'BRS Bravo' rootstock combinations surpass the state productivity, reaching almost twice as much (Table 1). In addition, these four combinations demonstrated consistency in high productivity in the two years evaluated (Table 1).

The first two principal components (PC) explain more than 92% of the scion-rootstock combination variability (Figure 1). Variables technological index, juice yield, soluble solids (ºBrix), pH and ratio showed positive correlation with principal component 1 (PC1) (Figure 1). Variable acidity, conversely, presented positive correlation in relation to principal component 2 (PC2) (Figure 1).

The 'Lima' orange combination with the three rootstocks showed the highest correlation with principal component 1 (Figure 1). This can explain the good quality in relation to technological index, juice yield, soluble solids (°Brix), pH and ratio. Regarding principal component 2, these combinations showed very low acidity (Figure 1). However, one of the main characteristics of the 'Lima' orange is its low acidity (OLIVEIRA et al., 2010b). 'Lima' orange scion in combination with 'BRS Bravo' rootstock has already demonstrated good fruit quality in the state of Amazonas (SANTOS, 2019).

Other combinations that presented good correlation with principal component 1 and good fruits in relation to technological index, juice yield, soluble solids (°Brix), pH and ratio are 'Pêra', 'Salustiana', 'Valencia Tuxpan' and 'Westin' with 'BRS Bravo' rootstock and 'Pêra D6' scion with 'Rangpur lime SC' lime rootstock (Figure 1). Of these, only the 'Westin' with 'BRS Bravo' combination has low acidity (Figure 1). Thus, the 'BRS Bravo' rootstock

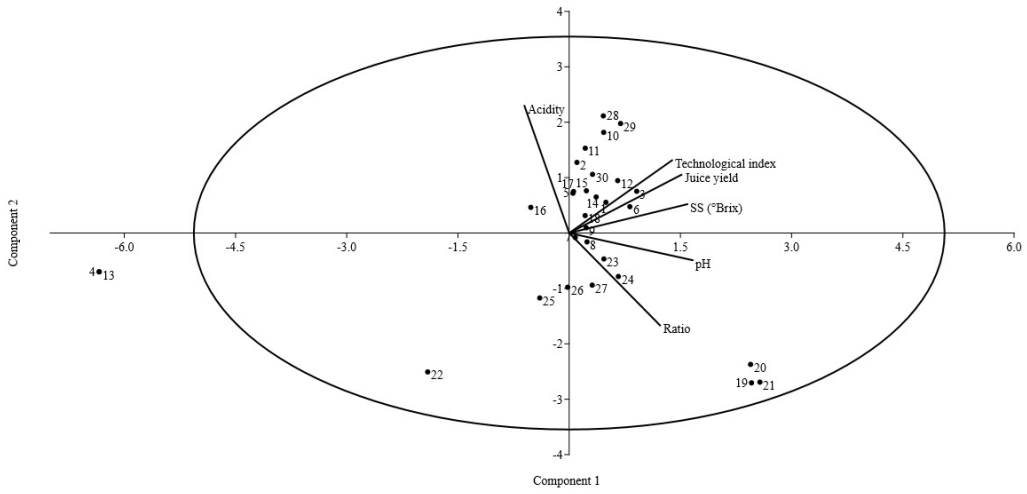

Figure1 - Principal component analysis (PCA), with correlation circle (95% confidence ellipse) for the 30 rootstock-scion combinations. Rio Preto da Eva, AM, 2019.

Captions: Variables: i. titratable acidity, ii. technological index, iii. juice yield, iv. soluble solids, v. pH, ix. ratio. Scion-rootstock combinations: 1 - 'Pera' x 'Sunki Tropical'. 2 - 'Pera' x 'Rangpur lime SC'. 3 - 'Pera' x 'BRS Bravo'. 4 - 'Salustiana' x 'Sunki Tropical'. 5 - 'Salustian'a x 'Rangpur lime SC'. 6 - 'Salustiana' x 'BRS Bravo'. 7 - 'Rubi' x 'Tropical Sunki'. 8 - 'Rubi' x 'Rangpur lime SC'. 9 - 'Rubi' x 'BRS Bravo'. 10 - 'Valencia Tuxpan' x 'Sunki Tropical'. 11 - 'Valencia Tuxpan' x 'Rangpur lime SC'. 12 - 'Valencia Tuxpan' x 'BRS Bravo'. 13 - 'Diva' x 'Sunki Tropical'. 14 - 'Diva' x Rangpur lime SC'. 15 - 'Diva' x 'BRS Bravo'. 16 - 'Pineapple' x Tropical Sunki. 17 - 'Pineapple' x Rangpur lime SC'. 18 - 'Pineapple' x 'BRS Bravo'. 19 - 'Lime' orange x 'Sunki Tropical'. 20 - 'Lime' orange x Rangpur lime SC'. 21 - 'Lima' orange x 'BRS Bravo'. 22 - 'Westin' x Sunki Tropical. 23 - 'Westin' x Rangpur lime SC'. 24 - 'Westin' x BRS Bravo. 25 - 'Cara Cara' x 'Sunki Tropica'l. 26 - 'Cara Cara' x 'Rangpur lime SC'. 27 - 'Cara Cara' x BRS Bravo. 28 - 'Pera D6' x 'Tropical Sunki'. 29 - 'Pera D6' x 'Rangpur lime SC'. 30 - 'Pera D6' x 'BRS Bravo'.

stands out with good fruit quality with four different scions and can be indicated to obtain good quality orange juice (LIU et al., 2023). In addition, these combinations have the potential to reach levels higher than the minimum required soluble solids equal to or greater than 10° Brix by the identity and quality standards for orange juice, regulated by Normative Instruction No. 37 of October 1, 2018.

'Pêra', 'Valencia Tuxpan', 'Pineapple' and 'Pêra' D6' scions with 'Sunki Tropical' tangerine rootstock, 'Pêra', 'Salustiana', 'Valencia Tuxpan', ´Diva' and ' Pineapple' scions with 'Rangpur lime SC' lime rootstock and 'Rubi', 'Diva', 'Pineapple' and 'Pêra D6' scions with 'BRS Bravo' rootstock showed acidic and low quality fruits. 'Rubi' with 'Sunki Tropical' mandarin rootstock, 'Rubi' and 'Westin' scions with 'Rangpur lime SC' lime rootstock and 'Cara Cara' with 'BRS Bravo' combinations, in addition to having low quality fruits, also have low acidity. Therefore, these 17 combinations have fruits that do not meet the desired characteristics.

'Salustiana', 'Diva', 'Westin', 'Cara Cara' scions with 'Sunki Tropical' mandarin rootstock and 'Cara Cara' with 'Rangpur lime SC' lime tree combinations showed negative correlation with principal components 1 and 2. Thus, they have low quality in all variables under study. These combinations also have low productivity and little adaptability to the region.

CONCLUSION

'Pineapple' scion with 'Sunki Tropical' and 'BRS Bravo' rootstocks can be productive alternatives to the traditional 'Pêra' orange under 'Rangpur' lime tree combination in the state of Amazonas.'Lima' orange tree with 'Sunki Tropical' mandarin, 'Rangpur lime SC' and 'BRS Bravo' lime rootstocks can be alternatives for the fresh market in the state of Amazonas. The combinations that showed good fruit quality are 'Pêra', 'Salustiana', 'Valência Tuxpan' and 'Westin' scions with 'BRS Bravo' rootstock, and 'Pêra D6' scion with 'Rangpur lime SC' lime rootstock.The results bring alternatives for the diversification of orchards in the state of Amazonas. The implementation of these combinations can increase productivity, also offer varieties for fresh consumption.

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DECLARATION OF CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHORS' CONTRIBUTIONS

José Ferreira da Silva and Cláudio Luiz Leone Azevedo conceptualization. Milena Dantas Ribeiro, Gustavo Brazão Buzaglo, Ana Francisca Tibúrcia Amorim Ferreira e Ferreira, Daniely Cunha da Silva, Laiane Sherly Gomes Torres carried out the formal analysis. José Ferreira da Silva supervised and project adminstration. Milena Dantas Ribeiro carried out the validation. Milena Dantas Ribeiro and Débora Clivati Faria Pereira prepared the draft of the manuscript. All the authors critically reviewed the manuscript and approved the final version.

REFERENCES

BASTOS, D. C. et al. Cultivares copa e porta-enxertos para a citricultura brasileira. **Informe Agropecuário**, v.35, p.36-45, 2014. Available from: <http://www.alice.cnptia.embrapa.br/alice/handle/doc/1007492>. Accessed: May, 29, 2023.

BOWMAN, K. D. et al. Genetic modulation of Valencia sweet orange field performance by 50 rootstocks under huanglongbing-endemic conditions. **Frontiers in Plant Science**, v.14, p.1-24, 2023. Available from: <https://www.frontiersin.org/articles/10.3389/fpls.2023.1061663/full>. Accessed: May, 29, 2023. doi: 10.3389/fpls.2023.1061663.

CAIXETA, M. P. et al. Phytophthora species associated with root rot in citrus orchards in Paraná State, Brazil. **Summa Phytopathologica**, v.39, n.4, p.242-247, 2013. Available from: <https://www.scielo.br/j/sp/a/vNxk6J8StYcXkQzBFWQ3R9w/>. Accessed: May, 29, 2023. doi: 10.1590/S0100-54052013000400002.

CARVALHO, L. M. DE. et al. Promising rootstocks alternative to 'Rangpur' lime in the Coastal Tablelands of the state of Sergipe, Brazil. **Pesquisa Agropecuaria Brasileira**, v.51, n.2, p.1-12, 2016. Available from: <https://www.scielo.br/j/pab/a/tPVvvJP5gm4hh3qfjPGYXFm/?lang=pt>. Accessed: May, 29, 2023. doi: 10.1590/S0100-204X2016000200005.

CARVALHO, H. W. L. D. et al. Yield, fruit quality, and survival of 'Pera' sweet orange on eight rootstocks in tropical cohesive soils. **Pesquisa Agropecuaria Brasileira**, v.56, p.1-9, 2021. Available from: <https://www.scielo.br/j/pab/a/dhgGG3cZNXxTsfT4xpCRGkr/?lang=en>. Accessed: May, 29, 2023. doi: 10.1590/S1678-3921.pab2021.v56.02151.

CARVALHO, H. W. L. D. et al. Productive performance of 'Pera' sweet orange grafted onto 37 rootstocks in tropical cohesive soils under rainfed condition. **Scientia Horticulturae**, v.303, n.November, 2021, p.11, 2022. Available from: <https://www-sciencedirect.ez2.periodicos.capes.gov.br/science/article/pii/S0304423822003508?via%3Dihub>. Accessed: May, 29, 2023. doi: 10.1016/j.scienta.2022.111229.

CHAUDHRY, A. H. et al. A novel bud mutant of navel orange (*Citrus sinensis*) shows tolerance to chlorosis in acidic and magnesium-deficient soils. **Plant Physiology and Biochemistry**, v.196,

p.739-745, 2023. Available from: <https://www-sciencedirect.ez2.periodicos.capes.gov.br/science/article/pii/S0981942823001031>. Accessed: May, 29, 2023. doi: 10.1016/j.plaphy.2023.02.028.

FUNDECITRUS. **Estimativa da Safra de Laranja do Cinturão Citrícola de São Paulo/Sudoeste Mineiro**. 2024. Available from: <https://www.fundecitrus.com.br/pdf/pes_relatorios/2024_05_10_Estimativa_do_Cinturao_Citricola_2024-2025.pdf>. Accessed: Sept. 19, 2024.

GOMES. **Estatística experimental**. Piracicaba: ESALQ. ed.12, p.467, 1987.

IBGE. **Levantamento Sistemático da Produção Agrícola**. 2023. Available from: <https://sidra.ibge.gov.br/tabela/6588>. Accessed: May. 29, 2023.

IBGE. **Levantamento Sistemático da Produção Agrícola**. 2024a. Available from: <https://sidra.ibge.gov.br/tabela/6588#resultado>. Accessed: Sept. 20, 2024.

IBGE. **Produção agropecuária**. 2024b. Available from: <https://www.ibge.gov.br/explica/producao-agropecuaria/laranja/br>. Accessed: Sept. 19, 2024.

IDAM. Instituto De Desenvolvimento Agropecuário E Florestal Sustentável Do Estado Do Amazonas. **Revista Idam**, Ater Nº1, 2019. Available from: <http://www.idam.am.gov.br/wp-content/uploads/2020/05/Revista-IDAM-Projetos-Prioritários-CDR_19-dezembro-2019.pdf>. Accessed: May, 29, 2023.

INSTITUTO ADOLFO LUTZ. **Métodos físico-químicos para análise de alimentos**. São Paulo: Instituto Adolfo Lutz, 2008. p.1020.

KUNWAR, S. et al. Field performance of 'Valencia' orange trees on diploid and tetraploid rootstocks in different huanglongbing-endemic growing environments. **Scientia Horticulturae**, v.309, n.April 2022, p.111635, 2023. Available from: <https://www-sciencedirect.ez2.periodicos.capes.gov.br/science/article/pii/S0304423822007506?via%3Dihub>. Accessed: May, 29, 2023. doi: 10.1016/j.scienta.2022.111635.

LIU, X. et al. Effects of rootstocks on the flavor quality of huanglongbing-affected sweet orange juices using targeted flavoromics strategy. **RSC Advances**, v.13, n.8, p.5590-5599, 2023. Available from: <https://pubs-rsc-org.ez2.periodicos.capes.gov.br/en/content/articlelanding/2023/RA/D2RA08182B>. Accessed: May, 29, 2023. doi: 10.1039/d2ra08182b.

MARTINS, C. R. et al. Performance of the pineapple sweet orange on different rootstocks. **Bioscience Journal**, v.36, n.2, p.458-472, 2020. Available from: <https://seer.ufu.br/index.php/biosciencejournal/article/view/46413/28099>. Accessed: May, 29, 2023. doi: 10.14393/BJ-v36n2a2020-46413

OLIVEIRA, L. A. D. **Manual de laboratório: análises físico-químicas de frutas e mandioca**, Cruz das Almas: Embrapa Mandioca e Fruticultura, 2010a. 248 p.

OLIVEIRA, R. P. DE et al. **Laranjeiras Sem Acidez**. Pelotas: Embrapa Clima Temperado, 2010b. 23p. (Documento, 298).

POMPEU JUNIOR, J.; BLUMER, S. Citrus sudden death: susceptibility of rangpur lime selections and the use of interstocks. **Revista Brasileira de Fruticultura**, v.30, n.4, p.1159-1161, 2008. Available from: <https://www.scielo.br/j/rbf/a/tjB3hWj3CqHrnbQyF6fFCnN/?lang=pt>. Accessed: May, 29, 2023. doi: 10.1590/S0100-29452008000400052.

POMPEU JUNIOR, J. et al. 'Valencia' sweet orange trees grafted on trifoliate hybrids. **Scientia Agricola**, v.59, n.1, p.93-97, 2002. Available from: <https://www.revistas.usp.br/sa/article/view/21698/23722>. Accessed: May, 29, 2023.

RIBEIRO, L. DE O. et al. 'Tropical Sunki' mandarin and hybrid citrus rootstocks under 'Pera' sweet orange in cohesive soil and As climate without irrigation. **Bragantia**, v.80, p.1-14, 2021. Available from: <https://www.scielo.br/j/brag/a/HMyzwL8xx5PLGJfhdXkGhxM/>. Accessed: May, 29, 2023. doi: 10.1590/1678-4499.20200407.

SANTOS, J. C. **Avaliação inicial de combinações de Copa/Porta-enxertos de Citros na Região Metropolitana de Manaus, AM**. 2019. 129f. Tese (Doutorado em Agronomia Tropical) - Universidade Federal do Amazonas.

SANTOS, J. C. et al. Initial production and fruit quality of scion-rootstock combinations in orange trees in amazonas. **Revista Brasileira de Fruticultura**, v.43, n.3, p.1-11, 2021. Available from: <https://www.scielo.br/j/rbf/a/83zTvMNqNrpHRwZsJwC6WxH/?lang=en>. Accessed: May, 29, 2023. doi: 10.1590/0100-29452021156.

SILVA, S. E. L. DA et al. **Produção de Mudas de Laranja**. Manaus: Embrapa Amazônia Ocidental, 2002. 6p. (Circular Técnica, 14).

SOUZA, L.A.G. et al. Ciência e Tecnologia aplicada aos Agroecossistemas da Amazônia Central. In: MARTEL, J.H.I. et al. **Presença de "declínio" em laranjeiras-doces enxertadas nos porta-enxertos limoeiros 'Cravo' e 'volkameriani' em Manaus**, 2018. Cap.10, p.111-119.

TAZIMA, Z. H. et al. Comportamento de clones de laranja 'Valência' na região norte do Paraná. **Revista Brasileira de Fruticultura**, v.30, p.970-974, 2008. Available from: <https://www.scielo.br/j/rbf/a/j3ZH97hc4F4nMPsj7bv364r/?lang=pt>. Accessed: May, 29, 2023. doi: 10.1590/S0100-29452008000400022.

USDA-FAS. Citrus: World Markets and Trade. United States Department of Agriculture. **Foreing Agricultural Service**, n.January, p.1-15, 2024. Available from: <https://apps.fas.usda.gov/psdonline/circulars/citrus.pdf>. Accessed: May, 12, 2024.