

## Satisfaction of the producers and orange production trends in the main Brazilian citrus belt

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### ABSTRACT

The objective of this work was to evaluate the producers' satisfaction with the sweet orange (*Citrus sinensis*) cultivation, and the production trends in the main Brazilian citrus belt – in the states of São Paulo and Minas Gerais (the Triângulo Mineiro / southwest Minas Gerais). Interviews were performed with 260 producers from 922 stratified properties [with 20,000 trees (small), from 20,001 to 100,000 (medium), and more than 100,000 trees (large)]. The analysis with 93% confidence level and 5% sampling error showed that 92% of properties are owned, 28% of them are irrigated, 61% have less than 20,000 trees, and 81% have been cultivated for more than 20 years; besides, 45% producers seek to plant the cultivar 'Pera Rio', and 53% intend to use the 'Swingle' citrumelo rootstock. The preferred regions for planting are Avaré, Triângulo Mineiro, and São José do Rio Preto. The biggest concerns over the orange production in the Citrus Belt are the adverse climatic factors in its north and northwest sectors, and the phytosanitary issues in the in its southwest, south and center sectors. Despite the reduction trend of the number of properties with orange in the last decades, it can be attenuated, given the satisfaction of the producers with the crop, mainly from the part of the larger ones. This can be confirmed by the decision of establishing new plantings in 69% (large), 48% (medium), and 36% (small) of the properties.

**Index terms:** *Citrus sinensis*, adverse climatic factors, cultivation regions, phytosanitary problems, property profile.

### Satisfação dos produtores e tendências da produção da laranja no principal cinturão citrícola brasileiro

### RESUMO

O objetivo deste trabalho foi avaliar a satisfação dos produtores quanto ao cultivo da laranja-doce (*Citrus sinensis*) e as tendências da produção, no principal cinturão citrícola brasileiro – nos estados de São Paulo e Minas Gerais (Triângulo Mineiro / sudoeste de Minas Gerais). Foram entrevistados 260 produtores de 922 propriedades estratificadas [até 20.000 árvores (pequenas), de 20.001 a 100.000 (médias), e mais de 100.000 árvores (grandes)]. A análise com 93% de nível de confiança e 5% de erro amostral mostrou que 92% das propriedades são próprias, 28% são irrigadas, 61% têm menos de 20 mil árvores, e 81% são cultivadas há mais de 20 anos; além disso, 45% dos produtores desejam plantar a cultivar 'Pera Rio', e 53% dos produtores desejam utilizar o porta-enxerto citrumelo 'Swingle'. As regiões preferidas para plantio são Avaré, Triângulo Mineiro e São José do Rio Preto. Os maiores receios quanto à produção de laranja no cinturão citrícola são os fatores climáticos adversos, em seus setores norte e noroeste,

### Ideias centrais

- A produção da laranja vem perdendo área e número de propriedades em São Paulo e no Triângulo/Sudoeste Mineiro (Cinturão Citrícola).
- Visto a satisfação dos produtores nas safras 2017, 2018 e 2019, esta tendência pode estar perdendo força.
- A satisfação dos produtores para com sua atividade é maior em grandes propriedades.
- Os principais riscos à produção dentro do Cinturão Citrícola são questões fitossanitárias (produtores do Centro, Sul e Sudoeste) e climáticas adversas (produtores do Norte e Noroeste).

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e os problemas fitossanitários em seus setores sudoeste, sul e centro. Apesar da redução do número de propriedades com laranja nas últimas décadas, essa tendência pode ser atenuada pela satisfação com a cultura principalmente da parte dos maiores produtores. Isso pode ser confirmado pela decisão de estabelecer novos plantios em 69% (grandes), 48% (médias) e 36% (pequenas) das propriedades.

**Termos para indexação:** *Citrus sinensis*, fatores climáticos adversos, perfil de propriedades, problemas fitossanitários, regiões de cultivo.

## INTRODUCTION

Brazil is the world's largest producer of sweet orange (*Citrus sinensis*), with an area destined to harvest of 595,300 ha in 2018, out of which 376,600 ha are cultivated in São Paulo state, that is the largest national producer (IBGE, 2018). The main orange-producing region in Brazil is the Citrus Belt represented by the states of São Paulo and Minas Gerais (Triângulo Mineiro / southwest of Minas Gerais), totaling 407,700 ha in 2020 (Fundecitrus, 2020a). Although protagonist, the Citrus Belt lost some harvested area and number of properties with orange in recent years. From 1997 to 2016, in São Paulo only, there was 45.5% decrease in the harvested area. In the 2017/2018 agricultural year, orange was present in 5,882 properties within the Citrus Belt (Fundecitrus, 2018); however, in the 1995/1996, this crop was cultivated in 35,883 properties, in São Paulo state only (São Paulo, 2018). Beyond the reduction of the number of properties, there was a reduction of the planted area with orange.

According to Camargo et al. (2011), the area with fruit trees decreased 14.4% in São Paulo state, from 1996 to 2008, due to the retraction of orange production as its main crop. Some reasons were considered by Camargo et al. (2011), and Erpen et al. (2018) to explain the reduction of both the harvested area and the number of properties with orange in São Paulo state, such as the variation of prices paid to producers, the presence of alternative crops, mainly sugar cane, and the occurrence of diseases such as citrus canker (caused by *Xanthomonas citri* subsp. *citri*.) and greening or HLB (associated with *Candidatus Liberibacter* spp.). These reductions generated uncertainties and increased the production costs due to the higher expenses with labor and phytosanitary management. Besides the reduction of the planted area with oranges, there was a displacement of production within the Citrus Belt, and some municipalities gained protagonism in detriment of others. Itápolis, Bebedouro and Barretos, in the center and north of the Citrus Belt, which had in 1996, respectively 32,000, 29,800 and 16,800 ha, reduced their cropping areas in the same sequence to 10,504, 6,250, and 7,449 ha in 2016. However, municipalities in the southwest of São Paulo, with little tradition until 1996, such as Botucatu, Iaras, and Avaré, had expressive areas cultivated with orange in 2016, 11 above 6,700 hectares. Casa Branca, in São Paulo state, had in 1996, 18,400 ha, and in 2016, 13,000 ha cultivated with orange (IBGE, 2016).

Some facts have been reported as agents of contribution to the displacement of the orange cultivation, such as the pressure of diseases, mainly HLB, in the center and south of the Citrus Belt, as well as adverse climatic factors to production in the north and northwest sectors, and the substitution of orange for sugarcane in traditional citrus areas (Aguiar, 2012; Aguiar & Souza, 2014; Fundecitrus, 2018, 2020a).

Between 2006 and 2016, there was an increasing number of days with temperatures above 35 °C, especially in the northernmost region of São Paulo, in important municipalities of production as Barretos, Bebedouro, Jales and Votuporanga. However, in municipalities such as Franca, Avaré, and Botucatu, this phenomenon was not observed (Crestana et al., 2017). In search of a milder climate for production, and due to the need for irrigation, citrus production in São Paulo is moving from the north region to municipalities such as Botucatu (Brito, 2004), in the southwest of the state (Fundecitrus, 2020a).

Under this scenario, the general goal of this research was to evaluate the satisfaction of producers with the orange cultivation in the last three harvests (2017, 2018, and 2019), and to identify the production trends for future investments. In order to fulfill the general aim, the following specific

objectives were pursued: to evaluate the degree of satisfaction and propensity for new plantings, preferred planting regions, agronomic aspects (orange cultivars, rootstocks, irrigation and planting density), and the greatest future risks to production, from the producers' perspective.

The research has socioeconomic relevance to support public policies to help understand the expectations and trends of orange producers in the main citrus region in Brazil. There is still managerial relevance because of the decrease of area and number of properties cultivated with orange. These facts have some impacts by causing a lower supply of fruit with a resulting increase of raw material prices. In extreme cases, these facts generates idleness in factories. For the production chain, fewer properties may mean less demand for inputs, services and labor. The displacement of production to other regions, especially to the southwest, may impact on greater freight, since the large orange processing facilities are still installed in the traditional production sectors, that is the center, south and north. There is a need for more in-depth studies to investigate these impacts and trends. It is important to consider that the survey reflected the opinion of 260 independent suppliers, randomly sampled from a single orange processing industry in the Citrus Belt.

## MATERIAL AND METHODS

The research used the application of structured interviews with producers of orange cultivation, with properties within the Citrus Belt, a region that comprises the largest concentration of the commercial production of orange in Brazil. It covers municipalities in São Paulo state, and the Triângulo Mineiro and southwest regions of Minas Gerais state (Fundecitrus, 2020a). The interview questions (Appendix), all closed, were applied in person or by phone call with the producer, or the property manager, each reflecting the reality of a property with orange. All interviews were applied using a digital tablet device. Trained staff in possession of this equipment interviewed the respondent on his routine or scheduled visits, as well as by telephone. The survey was conducted in the second half of 2019.

At the end of the research application, an Excel database was generated, later tabulated and analyzed. The population (260 suppliers) to be studied comprised properties with orange cultivation belonging to a registration portfolio (fruit suppliers) of an orange juice processing company, in a total population of 922 suppliers). The sampling plan stratified with a proportional distribution of the selected samples within the strata (Bussab & Morettin, 2002). This sampling plan was selected to obtain a more representative and comprehensive sample of the population in question. Three strata were used and followed the number of orange trees (plants) that each property had, as follows: up to 20,000 trees (plants); from 20,001 to 100,000 trees (plants), and more than 100,000 trees (plants). The division of the regions was chosen according to the geographic regions defined by Fundecitrus (2020a), for which the Citrus Belt has 5 sectors, involving 12 regions, as follows: north sector (Bebedouro and Triângulo Mineiro regions); northwest sector (Votuporanga and São José do Rio Preto regions); center sector (Matão, Duartina, and Brotas regions); south sector (Porto Ferreira and Limeira regions); and southwest sector (Itapetininga and Avaré regions). The 12 regions were stratified equally (tree strata) in number of trees, to ensure a better representation of the properties within the belt, as well as a classification by property size.

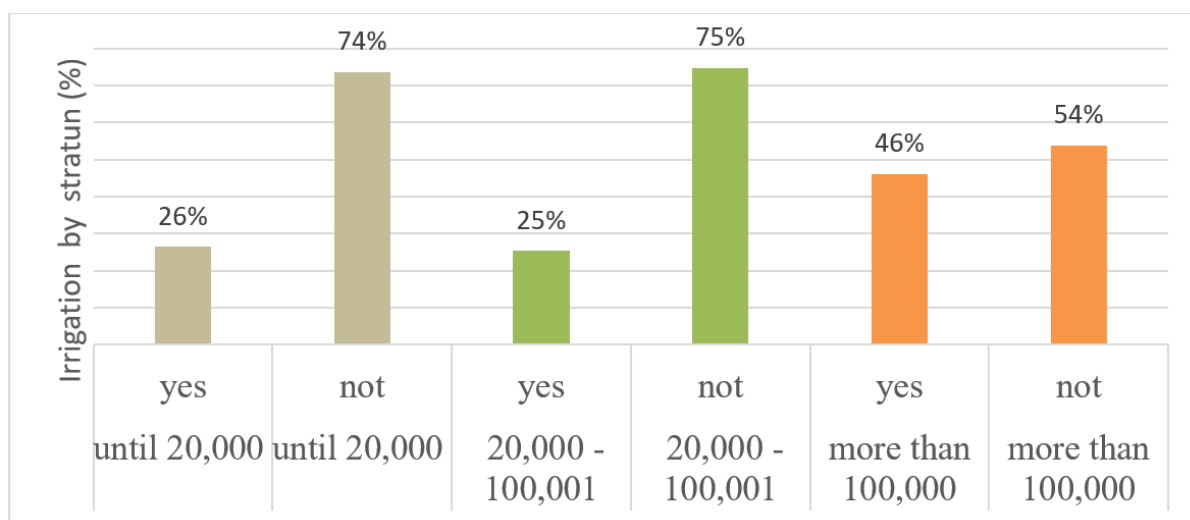
The proportional distribution respected the distribution of the analyzed population (922 properties with orange). For instance: if one stratum X has 5% of the population's properties, then 5% will be allocated to that stratum. The choice of the properties selected within each stratum was made at random, allowing of an inference on a certain characteristic in the responses. An estimate of population proportion with finite population was performed, with a sampling error of 5% and a 95% confidence level according to the following equation:

$$n = \frac{N \cdot \hat{p} \cdot \hat{q} \cdot (Z_{\alpha/2})^2}{\hat{p} \cdot \hat{q} \cdot (Z_{\alpha/2})^2 + (N-1) \cdot E^2} \dots\dots\dots(1)$$

in which:  $N = 922$  is the total number of the supplier population,  $E = 0.05$  is the sampling error,  $Z_{\alpha/2}$  is the critical value of the normal distribution and corresponds to the desired degree of confidence; and  $p$  and  $q$  are the probabilities of individuals belonging to and not belonging to population, respectively. As the values of  $p$  and  $q$  are not known, we adopt a conservative approach and replace the expression  $\hat{p} * \hat{q}$  with 0.25 (Bussab & Morettin, 2002). According to the Equation (1), the ideal number of samples for research would be 272 questionnaires answered; however, due to the unavailability or refusal of some respondents, it was only possible to carry out 260 questionnaires. With this decrease, the desired confidence level was affected and, after fixing the number of performed samples, and the number of the population and the sampling error of 5% in Equation (1), we obtained 93% confidence level.

## RESULTS AND DISCUSSION

The analyses of the results show that out of the 260 questionnaires, 159 or 61% were answered by orange producers from small properties (up to 20,000 orange trees), 75 (29%) were answered by producers from intermediate properties (from 20,001 to 100,000 trees), and 26 or 10% were answered by producers from large properties (with more than 100,000 trees). Therefore, the sampling applied indicates that the orange cultivation is an important agricultural activity, generating income and jobs, which still maintains the characteristics and model of small properties that are important for the distribution of income and mitigation of the rural exodus. It is important to consider that the total orange production is mainly present in large properties. Out of the 260 properties, 238 (92%) were owned by the producer, and 8% were leases. A total of 81% producers has been growing orange for at least 20 years, therefore, it is an activity with experienced and traditional producers, with few entrants. Most of the surveyed properties, 187 (72%), do not use irrigation. When irrigation was classified by size strata, properties greater than 100,000 trees showed a higher percentage of irrigated areas (Figure 1).



**Figure 1.** Irrigation by farm size in a total of 260 farms surveyed in the Citrus Belt.

The survey analysis shows that producers from 187 nonirrigated properties (187), only 27% had the intention to irrigate. The majority (73%) intended to continue producing orange in rainfed cultivation. The regions Triângulo Mineiro, Altinópolis, and Bebedouro, which form the north sector of the Citrus Belt, had the highest percentage of irrigated properties. Out of 84 producers interviewed, 36 had properties with irrigation. However, in the regions Avaré and Itapetininga, that belong to the southwest sector, out of the 19 researched properties, none had irrigation and only one producer of

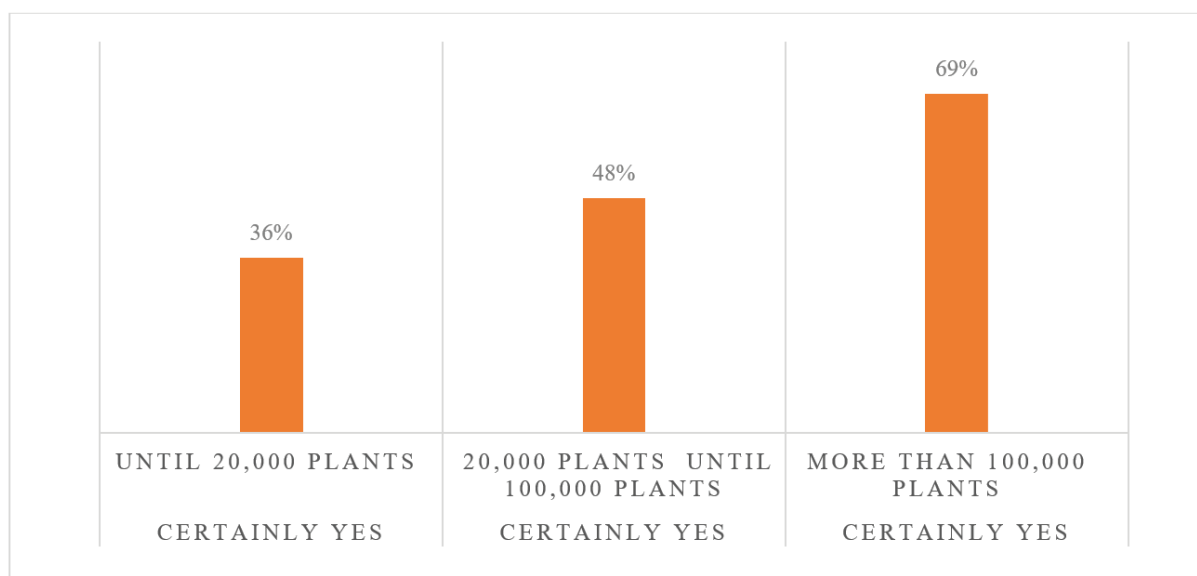
these intendeds to use irrigation. These two sectors reflect within the Citrus Belt the greatest discrepancies between the irrigated and nonirrigated areas of the survey, respectively 42.8% and 0%. In accordance with these results, Fundecitrus (2018) identified, in the 2018/2019 period, 46.8% participation in the irrigated area of the Citrus Belt, in the north sector (Triangle Mineiro, Bebedouro and Altinópolis), while 4.2% participation only, in the southwest sector (Avaré and Itapetininga), with.

The survey shows most producers' satisfaction with the activity, for the different strata, in the last three orange harvest seasons (2017, 2018, and 2019) (Table 1).

**Table 1.** Percentage of satisfaction with the orange crop by size stratum in the harvests: 2017, 2018 and 2019.

Degree of satisfaction/ size stratum	strongly agree	partially agree	indifferent	partially disagree	strongly disagree
Up to 20,000 trees	36%	38%	9%	9%	8%
20,000 to 100,000 trees	39%	50%	1%	7%	3%
More than 100,000 trees	54%	46%	0%	0%	0%

Satisfaction with the activity may mean that the exit of producers will be reduced in the coming years. Among the small producers, 74% strongly and partially agreed with the affirmation that orange crop has been a good deal in the last three harvests; however, among the medium producers, 89% strongly or partially agreed with this statement. The greater the size stratum, the greater the satisfaction with the crop. The survey also captured from the orange producer the certainty of making new investments, according to property size. The larger the property, the greater the certainty of making investments in new orange plantations, that is, 69% for large, 48% for medium and 36% for small properties (Figure 2).

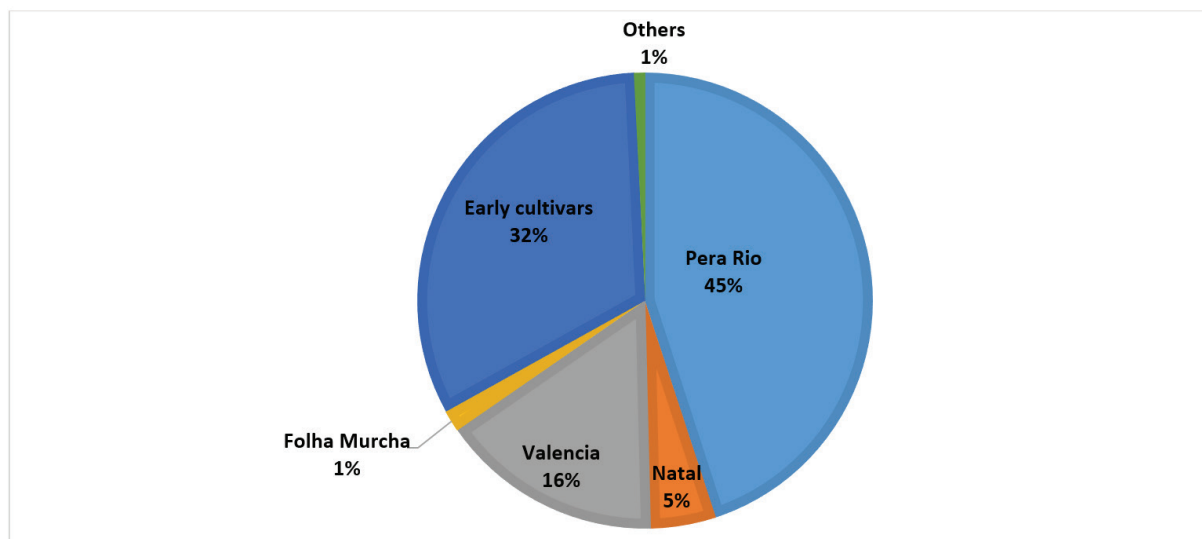


**Figure 2.** Certainty of carrying out new orange plantings by property size.

The results for accomplishment of new investments point out less certainty from producers with smaller properties, indicating risk of more concentration of production in large properties. Future research is necessary to identify the reason for this discrepancy in making new investments on whether

it is due to a lack of resources (owned or borrowed) or to the producers' fear of the risk of making these investments.

When asked which orange cultivar is preferred in new investments, 'Pera Rio' (with mid-season maturation) was preferred by 45% of the interviews. The early season cultivars 'Hamlin', 'Pineapple', 'Westin', 'Rubi' and 'Valencia Americana', added together, appeared soon after with 32% of the preferences (Figure 3).



**Figure 3.** Preferred orange cultivars in new plantings (investments).

The late season cultivars 'Natal', 'Valencia', and 'Folha Murcha' (withered leaf cultivar) had less preference by the questioned citrus growers, with 22% choices – which gives a good varietal distribution, generating harvest stratification throughout the year. According to Figueiredo (1991), orange cultivars have different characteristics and aptitude on whether the destination is preferably for juice or fresh fruit market. For Neves (2010), the diversification of cultivars stratifies the orange harvest throughout the year, avoiding the concentration of supply in a few months, which allows the farmer to sell its production at times of higher prices and the industry to extend the period of processing oranges for juice production. Planting diverse cultivars is also a way to manage diseases and reduce the impacts of climatic adversities.

The rootstock that producers will use in the orchard is very important because it will impact on the productivity and tolerance to main diseases. From the 260 questionnaires, 'Swingle' citrumelo and the rangpur lime (*limão Cravo*) led the planting intentions, respectively with 53% and 34% of preferences. The other 13% of planting preferences were distributed within 'Sunki' and 'Cleópatra' mandarins, citrandarins and other citrus (Figure 4). Other rootstocks are cultivars that were not listed in the questionnaire, and would be preferred by orange suppliers in new investments.

The risk of low diversification of rootstocks is mainly phytosanitary. In the event of new diseases or pests affecting these genetic materials, the entire production of the Citrus Belt may be susceptible. Some authors reported that many diseases and other factors have brought serious problems to the citrus industry, over the years, including mortality of trees; some of these problems are related to the genetic sensitivity of rootstocks, such as "tristeza" and sudden death diseases (Pompeu Junior & Bulmer, 2008; Damasio et al., 2014; Matsumura, 2016; Sampaio et al., 2016; Bassanezi et al., 2017). Due to its drought tolerance, rangpur lime became the preferred rootstock and, in 1995, 85% of the orange trees in São Paulo were grafted onto this rootstock (Bové & Ayres, 2007). However, in 1999, many trees were set to decline and died from sudden death disease, with an estimate of over a million dead trees in 2003. According to Santos et al. (2006), 'Swingle' citrumelo has a lower tolerance to water stress than the rangpur lime, requiring irrigation in regions where the water regime is more limited.

When implementing the orange orchard, which is a perennial culture, the producer cannot make a mistake in choosing the rootstock and cultivar, since the investment is for several years. The choice should be thought taking into account some factors, as follows: whether to use irrigation; the geographic region where the orchard will be installed; history of diseases in the region; the soil type; commercial preference (fresh fruit or juice industry), etc.

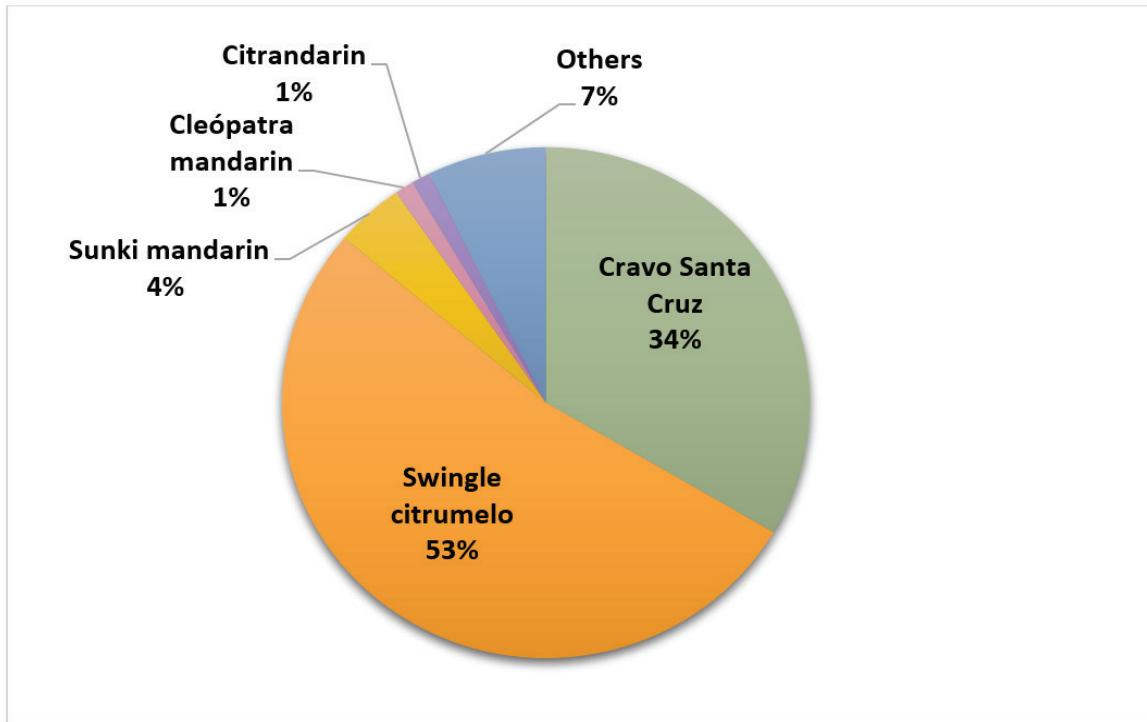


Figure 4. Preferred orange rootstocks in new plantings (investments).

The survey also showed the most used orange tree spacing (distances in meters between planting lines, and between trees within the row): 6 m x 3 m (555 trees ha<sup>-1</sup>, and 7 m x 3 m (476 trees ha<sup>-1</sup>), are preferred (Figure 5).

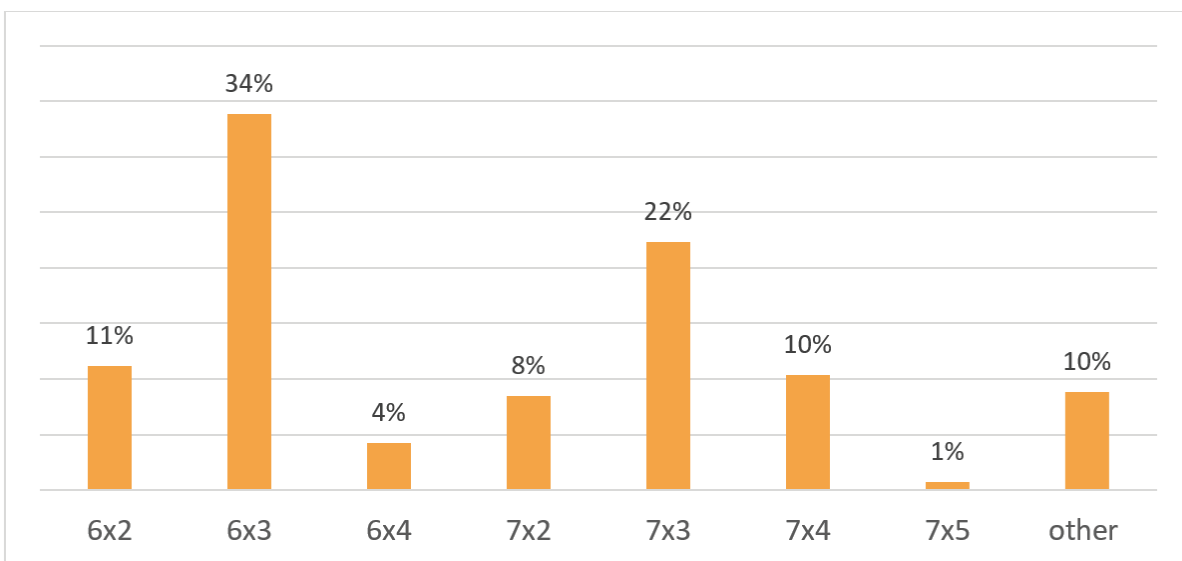
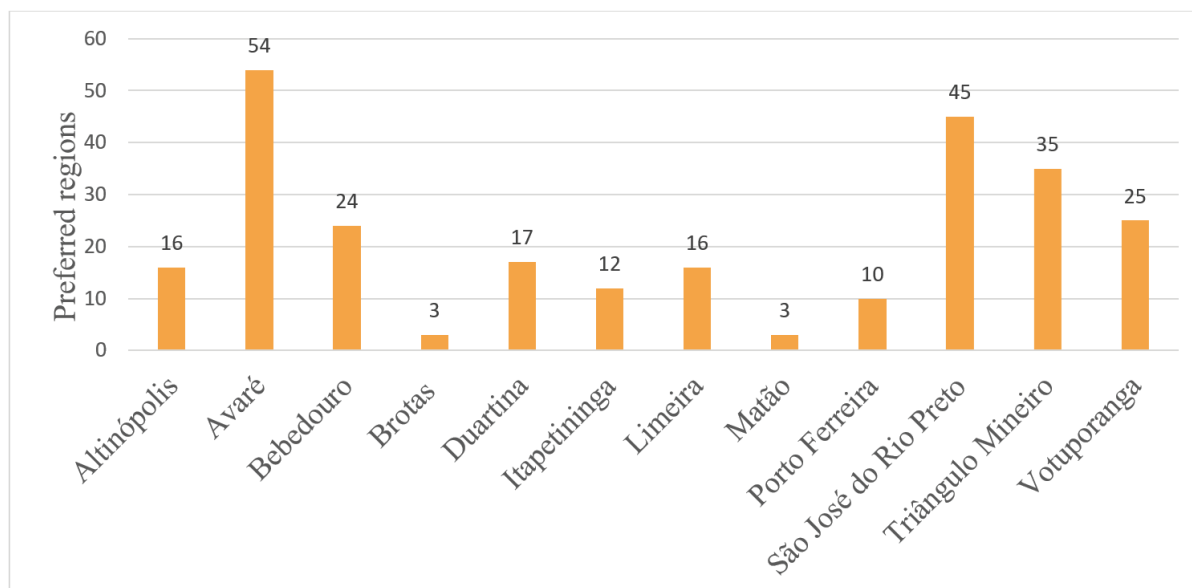


Figure 5. Preference (%) for spacing (m) between orange trees used by producers in new investments.

One of the main changes within the Brazilian Citrus Belt in the last decades was the number of trees used to cultivate citrus crop in one hectare. Orchards cultivated in 1980 and in 2017, within the Citrus Belt (São Paulo and Minas Gerais), had 340 and 668 trees ha<sup>-1</sup>, respectively, an increase of 96.47% (Fundecitrus, 2018). The planting of more trees per area promotes the increase of productivity, especially in the first years of growing, anticipating the return on investment to production, with importance in the management of HLB, attempting to mitigate the losses generated by the eradication of symptomatic trees (Stuchi & Girardi, 2010; Azevedo et al., 2015). Denser orchards cause a reduction of the space available for the development of trees, as well as the transit of machines, determining a greater competition for water and light in orchards in full production, which makes the use of pruning techniques inevitable (Franco, 2014). Therefore, the increase in the tree density, with a shorter distance between orange trees, is an agronomic technique that will be a trend in new plantings; however, this practice should be well planned by the citrus grower. Aiming at positive impacts, the technique requires other procedures for cultural management, such as thinning of trees by “pruning or the use of less vigorous rootstock varieties”.

Regardless of whether the producers would move or not, they were asked in which region of the Citrus Belt they would prefer to plant new orchards (Figure 6). The answers are important to verify the movement of new plantations in different geographic regions.



**Figure 6.** Preferred regions for new plantings by 260 producers surveyed within the Citrus Belt.

Out 260 respondents, 54 said they would plant orange in the Avaré region. The questioned producers showed low preference for orange planting in the center of São Paulo state (Brotas, Matão, and Duartina), and in the south (Limeira and Porto Ferreira) – traditional in production. According to the Fundecitrus survey on HLB, in 2018, the disease is present in almost all Citrus Belt; however, some regions are more affected than others (Fundecitrus, 2018). Regions at the edges of the Citrus Belt, such as Triângulo Mineiro, Votuporanga, and Itapetininga, have lower incidence of HLB, whereas the regions in the center and south sectors of the Belt have been severely attacked by the disease. The high incidence of HLB in the orchards of the center (Duartina, Matão, and Brotas) and south (Limeira and Porto Ferreira) explains the difficulty that the producers of these regions have been facing in the activity, and, therefore, the fear of making new investments in these regions.

When segmenting the analysis by sector for the potential risks to production, the phytosanitary factor was identified as of the most important future concern of producers in the southwest, south and center sectors, with 42%, 49% and 43% of responses, respectively (Table 2)



**Table 2.** Higher risks to production (%) by geographic productive sector for orange producers in the Citrus Belt.

Risk/sector	North	Northwest	Southwest	South	Center
Phytosanitary problems (%)	31%	29%	42%	49%	43%
Adverse climatic factor (%)	44%	54%	0%	25%	28%
Input price rise (%)	17%	7%	26%	13%	10%
Lack of labor for harvesting (%)	1%	4%	0%	2%	0%
Orange price fluctuations (%)	5%	6%	32%	11%	17%
Other causes (%)	2%	0%	0%	0%	2%
Total (%)	100%	100%	100%	100%	100%

The phytosanitary problems, mainly the high incidence of HLB in the center and south sectors (Fundecitrus, 2018), motivates the concern on these sectors by producers who identify the disease as a phytosanitary question of greatest threat. The climatic factor was seen by producers in the north and northwest sectors as the greatest potential risk, with 44% and 54% of the responses, respectively. Important economic issues, such as orange prices and high input prices, appear as a source of concern mainly for producers in the southwest, with 58% of positive responses. Fundecitrus (2020b) reported that in extreme cases, the adverse climate (high temperatures associated to water stress) can compromise the production and cause death of trees. In the 2020/2021 harvest within the Citrus Belt, long-term drought and intense heat stress caused irreversible damage, with the death of trees, in the north, northwest and center sectors. Brito (2004) justified, as part of the reasons for citrus growing to move to the southwest region, the need for irrigation in orchards. The southwest region has mean annual temperatures lower than the north and northwest sectors of the Citrus Belt.

## CONCLUSIONS

1. The degree of satisfaction of the orange producers is quite high in relation to the last three harvests (2017, 2018, and 2019), reaching 100% for the large farms, 89% for the medium farms, and 74% for the small farms, in adherence to their activity.

2. Larger properties have more certainty to make new orange plantations. The index varies from 69% in large properties to 36% in small properties, in a movement of concentration in the orange production.

3. For new plantings, the preferred scion cultivars are mid-season ‘Pera Rio’ (45%), followed by early season cultivars (32%) and late ones (23%), which gives a good varietal distribution; as for the rootstocks, preferences are for ‘Swingle’ citrumelo (53%), followed by rangpur lime (34%), and others (13%), indicating a high concentration of genetic material that are agronomically undesirable.

4. Orchards follow a trend of greater density between trees in the planting line, with a preference of 555 trees ha<sup>-1</sup> and the use of more irrigation in the north and less irrigation in the southwest; the preferred regions for planting are Avaré, São José do Rio Preto, and Triângulo Mineiro, all with less HLB incidence within the Citrus Belt.

5. Producers in the north and northwest sectors see adverse climate conditions as a major risk to the production in the future, whereas those in the south, center and southwest indicate the HLB disease as the most important risk.

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