2023-2024

TREE INVENTORY AND ORANGE CROP FORECAST FOR THE SÃO PAULO AND WEST-SOUTHWEST MINAS GERAIS CITRUS BELT

ACESSE O VÍDEO E ACOMPANHE A PESQUISA

Fundecitrus
SCIENCE AND SUSTAINABILITY IN CITRICULTURE

PES
Crop Forecast Survey

markestrat
Group

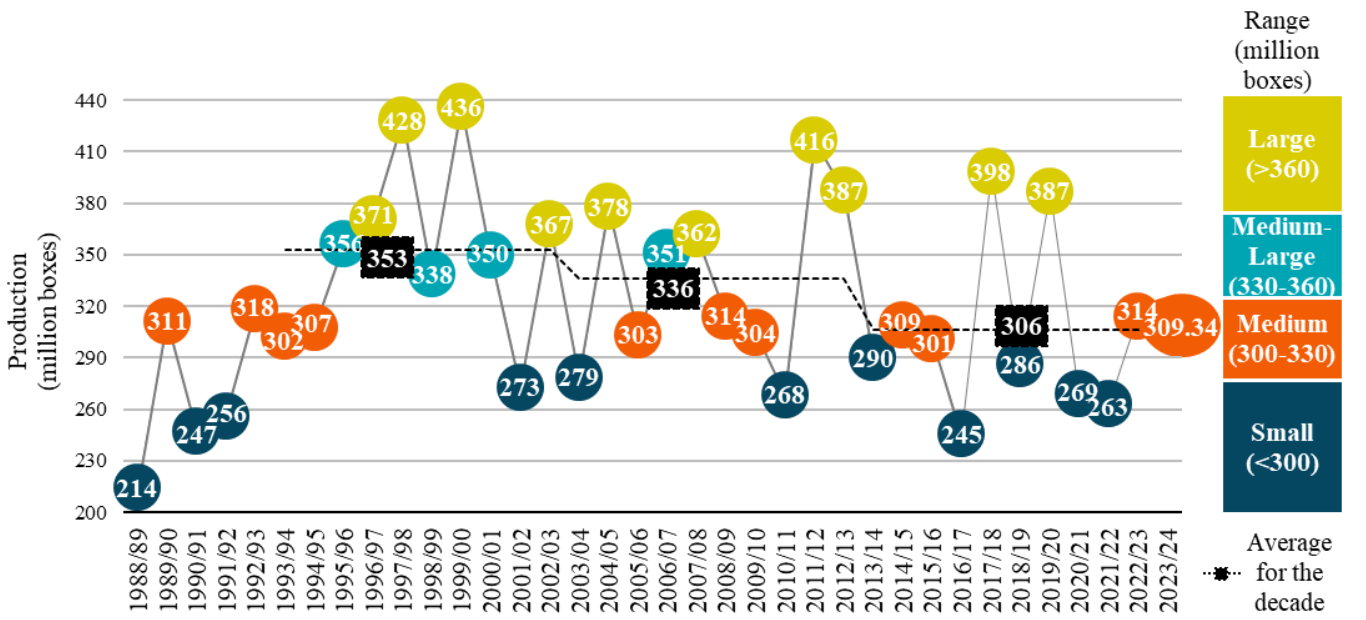
1 – 2023-2024 ORANGE CROP FORECAST

The 2023-2024 orange crop forecast for the São Paulo and West-Southwest Minas Gerais citrus belt, published on May 10, 2023 by Fundecitrus in cooperation with Markestrat and full professors at FEA-RP/USP and FCAV/Unesp, is 309.34 million boxes (40.8 kg). Total orange production includes:

- 56.11 million boxes of the Hamlin, Westin and Rubi varieties;
- 18.22 million boxes of the Valencia Americana, Seleta, Pineapple and Alvorada;
- 98.95 million boxes of the Pera Rio variety;
- 105.23 million boxes of the Valencia and Valencia Folha Murcha varieties;
- 30.83 million boxes of the Natal variety.

Approximately 27.02 million boxes are expected to be produced in the Triângulo Mineiro region.

The projected volume is lower only by 1.55 percent as compared to the previous crop, which totaled 314.21 million boxes. That minor difference maintains the production at the same level as in the previous crop season and within the average range for the last ten years, as shown in Graph 1. As compared to the average volume produced in the last decade, the current crop shows a slight increase of 1.04 percent.



Graph 1 - Orange production from 1988-1989 to 2022-2023 and 2023-2024 crop forecast
Sources: CitrusBR (1988-1989 to 2014-2015) and Fundecitrus (2015-2016 to 2023-2024)

One of the causes leading to that variation is the biennial bearing cycle, which results in a lower fruit load per tree in the off-year, such as this crop year. Therefore, just as the average number of fruits per tree increased approximately five percent in the previous crop, it decreased at the same rate in the current crop. Should the assumptions used to estimate the crop hold, that is, the increased average weight of oranges harvested and the reduced early fruit drop rate, it will be possible to minimize the impact resulting from the lower quantity of fruit.

The first significant rains after last year's water stress period were recorded in August in the regions of Avaré, Itapetininga and Duartina. Rains encouraged flowering of orange trees under rainfed conditions in those areas and were followed by heavier rains in September that fell in the same regions and also reached Bebedouro. In the remainder of the citrus belt, accumulated rains ranged from 40 to 80 millimeters. In October, heavy rains spread throughout the citrus belt, when flowering was observed in trees under rainfed conditions that had not yet produced their first bloom. A low-intensity second summer was also observed and reached only some cities mostly located in the North, Northwest and Central sectors. Since then,

monthly rainfall volumes have remained high until the publication of this forecast. The average rainfall in the citrus belt accumulated from August 2022 to April 2023 was 1,391 millimeters, which is 45 percent higher than the volume accumulated in the same period last year.

The high rainfall volume results from an extremely high frequency of rains in practically all the citrus belt. In Avaré, Itapetininga and Duartina, rains fell in more than half the days in September 2022, whereas in October and November 2022, rains fell in approximately 30 percent of the days throughout the citrus belt. In December 2022 and January 2023, the rainfall frequency increased even further, reaching an average 22 rainy days in each month.

Those consecutive rainfalls during flowering in addition to prolonged periods of soil wetting set favorable conditions for post-bloom fruit drop, a usually sporadic disease caused by a fungus that under continuous moisture at flowering affects flower petals and reduces fruit setting. Post-bloom fruit drop was mostly observed in the regions of Itapetininga, Avaré and Limeira, whereas in Duartina and Brotas it was less significant. Furthermore, it was more pronounced in debilitated plants in lowlands, of late varieties and older, whose trees had at least one bloom during the rainiest period.

Despite causing problems in some specific situations, rains generally favored the growth of fruit that already weigh slightly more than that in the past crop season at the same stage. Fruit is expected to continue to develop well until harvest is complete.

Forecasted rains above historical average in the citrus belt corroborate this expected increase in the average orange weight. This prognosis has the end of the La Niña phenomenon that lasted three years as its main indication, in addition to the expected onset of the El Niño phenomenon in the second half of 2023, according to information from Somar Meteorologia /Climatempo. That will make heavy rains that fell since last year throughout the citrus belt to continue during all crop season.

Thus, the weight of oranges at harvest is projected at 165 grams/5.83 ounces (247 fruits per box), which represents a 3.71 percent increase in relation to the average weight of 159 grams/5.61 ounces recorded in the previous crop (256 fruits per box) and is 1.23 percent above the average weight of the last 10 seasons (163 grams/5.75 ounces, resulting in 250 fruits per box). The regression model used to project the average fruit size is explained in item “2.4 – Fruits per Box.”

Another important aspect of the crop that was influenced by climatic conditions is the definition of the flowering profile. Rains that fell earlier this crop season as compared to the previous one caused an increased production of fruit from the first bloom in rainfed plots. That production added to first bloom fruit in irrigated groves (that account for 39 percent of the fruit bearing area) increased from 27.5 percent in the last crop to 36.2 percent in the current one. The second bloom represents 46.1 percent, the third bloom 16.3 percent, and the fourth bloom 1.5 percent.

Due to a higher percentage of fruit from the first bloom, harvest is expected to start earlier, allowing processing to gain speed faster than in the previous season. This sped-up harvest is advantageous since it may prevent the early fruit drop to reach rates as high as those in the previous crop when harvests lasted until April 2023. Other factors that help reduce fruit loss include soil moisture reserve, which has remained high since spring 2022, and the sharper decrease in the production in the South and Southwest, where fruit drop rate was higher in the last crop.

Despite these positive factors, greening incidence and severity continue to increase, posing intense pressure on fruit drop rate. That disease ranked second in causing fruit drop in the previous crop, accounting for more than a quarter of the total rate of 21.30 percent. Because of this scenario, the drop rate is projected at 21 percent, which is similar to last year’s.

Average yield this season is practically the same as last year's, of 918 boxes per hectare and 1.83 boxes per tree, as compared to the 912 boxes per hectare and 1.85 boxes per tree harvested in the 2022-2023 crop.

In the estimation of yield per variety, what stands out is a significant decline in the production of the Natal variety that presented the highest increase in the last crop season (33.2 percent) and now is expected to show the largest decrease, of 16.3 percent. That decreased yield for Natal may be attributed to several factors such as depletion of reserves, fruit remaining too long on trees due to delayed harvest and the incidence of post-bloom fruit drop, which was more pronounced in this variety as compared to the others. Conversely, the Pera Rio and Valencia varieties are expected to present increased yield. Tables 1 and 2 present yields by variety and variations in relation to the previous crop season.

Table 1 - Yield per hectare and variety for the 2018-2019 crop to the 2022-2023 crop[e]

Group of varieties	2018-2019	2019-2020	2020-2021	2021-2022	2022-2023	2023-2024[e]
	(boxes/ hectare)	(boxes/ hectare)	(boxes/ hectare)	(boxes/ hectare)	(boxes/ hectare)	(boxes/ hectare)
Hamlin, Westin and Rubi…	833	1,319	797	819	1,021	1,012
Other earlies.....	810	1,121	827	804	925	971
Subtotal for earlies.....	828	1,273	804	815	998	1,001
Pera Rio.....	633	943	671	653	811	848
Valencia and V.Folha Murcha.	826	998	739	838	940	970
Natal.....	765	1,082	803	734	978	818
Total.....	**756**	**1,045**	**737**	**760**	**912**	**918**

[e] Estimate

Table 2 - Variation in yield per hectare for varieties as compared to previous season's

Group of varieties	2019-2020 in comparison to 2018-2019		2020-2021 in comparison to 2019-2020		2021-2022 in comparison to 2020-2021		2022-2023 in comparison to 2021-2022		2023-2024[e] in comparison to 2022-2023	
	(boxes/ hectare)	%	(boxes/ hectare)	%	(boxes/ hectare)	%	(boxes/ hectare)	%	(boxes/ hectare)	%
Hamlin, Westin and Rubi…	486	58.4%	-522	-39.6%	22	2.8%	202	24.7%	-9	-0.9%
Other earlies.....	311	38.4%	-294	-26.2%	-23	-2.8%	121	15.0%	46	5.0%
Subtotal for earlies.....	445	53.8%	-469	-36.9%	11	1.4%	183	22.5%	3	0.3%
Pera Rio.....	310	48.9%	-272	-28.8%	-18	-2.7%	158	24.2%	37	4.6%
Valencia and V.Folha Murcha.	172	20.9%	-259	-26.0%	99	13.4%	102	12.2%	30	3.2%
Natal.....	316	41.3%	-279	-25.8%	-69	-8.6%	244	33.2%	-160	-16.3%
Total.....	**290**	**38.3%**	**-308**	**-29.5%**	**23**	**3.1%**	**152**	**20.0%**	**6**	**0.6%**

[e] Estimate

Regarding yield per sector, the North stands out, including the regions of Triângulo Mineiro, Bebedouro and Altinópolis, where the highest yield of the citrus belt is expected for this crop, of 1,088 boxes per hectare, representing an increase of 25.3 percent in relation to last crop. It is worth mentioning that in the previous season the North presented the lowest increase in yield in the citrus belt. As for the Southwest, sector that encompasses the regions of Avaré and Itapetininga, the second-lowest yield among the five sectors is expected at 852 boxes per hectare, whereas it was the best performing sector in the last crop. This alternation evidences the biennial bearing cycle but also relates to the incidence of post-bloom fruit drop, especially in the Southwest. Tables 3 and 4 present yields by sector and variations in relation to the previous crop season.

Table 3 - Yield per hectare of sectors for the 2018-2019 crop to the 2023-2024 crop[e]

Sector	2018-2019	2019-2020	2020-2021	2021-2022	2022-2023	2023-2024[e]
	(boxes/ hectare)	(boxes/ hectare)	(boxes/ hectare)	(boxes/ hectare)	(boxes/ hectare)	(boxes/ hectare)
North.....	606	1,070	648	804	868	1,088
Northwest.....	404	924	468	646	750	808
Central.....	707	1,032	667	729	928	887
South.....	770	936	725	699	926	872
Southeast.....	1,195	1,217	1,106	869	1,008	852
Total.....	**756**	**1,045**	**737**	**760**	**912**	**918**

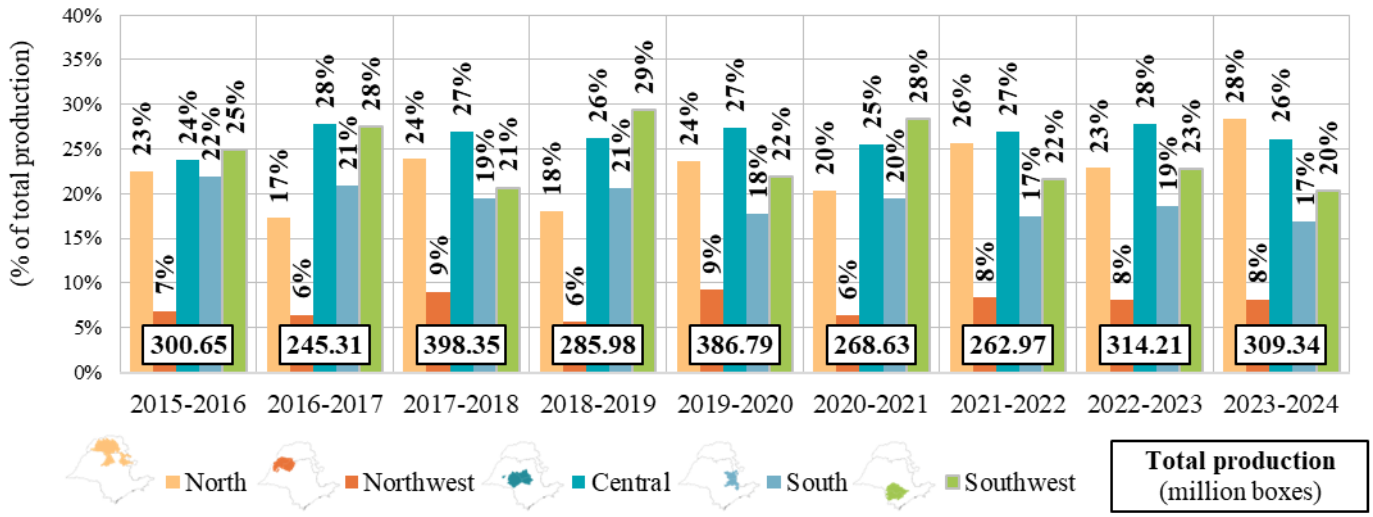
[e] Estimate

Table 4 - Variation in yield per hectare of sectors in relation to the previous crop season's

Sector	2019-2020 in comparison to 2018-2019		2020-2021 in comparison to 2019-2020		2021-2022 in comparison to 2020-2021		2022-2023 in comparison to 2021-2022		2023-2024[e] in comparison to 2022-2023	
	(boxes/ hectare)	%	(boxes/ hectare)	%	(boxes/ hectare)	%	(boxes/ hectare)	%	(boxes/ hectare)	%
North.....	464	76.6%	-422	-39.4%	156	24.1%	64	8.0%	220	25.3%
Northwest.....	520	128.7%	-456	-49.4%	178	38.0%	104	16.1%	58	7.7%
Central.....	325	46.0%	-365	-35.4%	62	9.3%	199	27.3%	-41	-4.4%
South.....	166	21.6%	-211	-22.5%	-26	-3.6%	227	32.5%	-54	-5.9%
Southwest.....	22	1.8%	-111	-9.1%	-237	-21.4%	139	16.0%	-156	-15.4%
Total.....	**289**	**38.2%**	**-308**	**-29.5%**	**23**	**3.1%**	**152**	**20.0%**	**6**	**0.6%**

[e] Estimate

According to data in Graph 2, it is possible to observe that production is distributed among sectors as follows: 28 percent in the North, 26 percent in the Central, 20 percent in the Southwest, 17 percent in the South and 8 percent in the Northwest.



Graph 2 - Share of sectors in total orange production in the 2015-2016 to 2023-2024 crops

2 – OBJECTIVE SURVEY METHOD FOR THE ORANGE CROP FORECAST

In order to perform this estimate, the objective method used in previous crop seasons was maintained, which is based on quantitative data – field measurements, counting and weighing of fruit – applied to the equation represented below.

$$\text{Forecast production} = \frac{\text{Bearing trees} \times \text{Fruit per tree} \times (1 - \text{Drop rate } \%) \times (1 - \text{CF } \%)}{\text{Fruit per box}}$$

where CF is the correction factor

Compiled results from the tree inventory and fruit stripping obtained throughout the survey were restricted, until the date of this publication, to the following professionals: Antonio Juliano Ayres (Fundecitrus general manager); Fernando Alvarinho Delgado (technical supervisor); Roseli Reina (specialist); Vinícius Gustavo Trombin (executive coordinator linked to Markestrat); Marcos Fava Neves (political-institutional and methodological coordinator linked to Markestrat and Full Professor at FEA-RP/USP); and José Carlos Barbosa (methodology analyst and Voluntary Full Professor at the department of Math and Science of FCAV/Unesp). All of them were subject to confidentiality obligations with regard to PES information before its announcement was made public, according to agreements signed between each of them and Fundecitrus. As for antitrust practices, they were all complied with through the adoption of measures necessary to prevent any communication or sharing of individual information with competitive content among the orange juice companies that collaborate with Fundecitrus in this project or between these and citrus growers.

Together with Fundecitrus president Lourival Carmo Monaco, the crop forecast was finalized on May 10, 2023 at 9:30 a.m., in an in-person meeting at Fundecitrus, with no external communication channel beyond participants. This year Professor Marcos Fava Neves participated by video-conference in only the presentation and discussion of the data. Following that, at 10 a.m., Fundecitrus president began the public announcement of the crop forecast at the Fundecitrus auditorium in Araraquara - SP, broadcast live at the Fundecitrus channel on YouTube (www.youtube.com/fundecitrus). Next, Fundecitrus general manager Antonio Juliano Ayres presented the detailed data.

After the crop forecast announcement, the Executive Summary of the 2023-2024 orange crop forecast was made available on the Fundecitrus website. The complete report including the 2022 tree inventory and the 2022-2023 orange crop forecast will be available on June 05, 2023, at www.fundecitrus.com.br.

2.1 – BEARING TREES

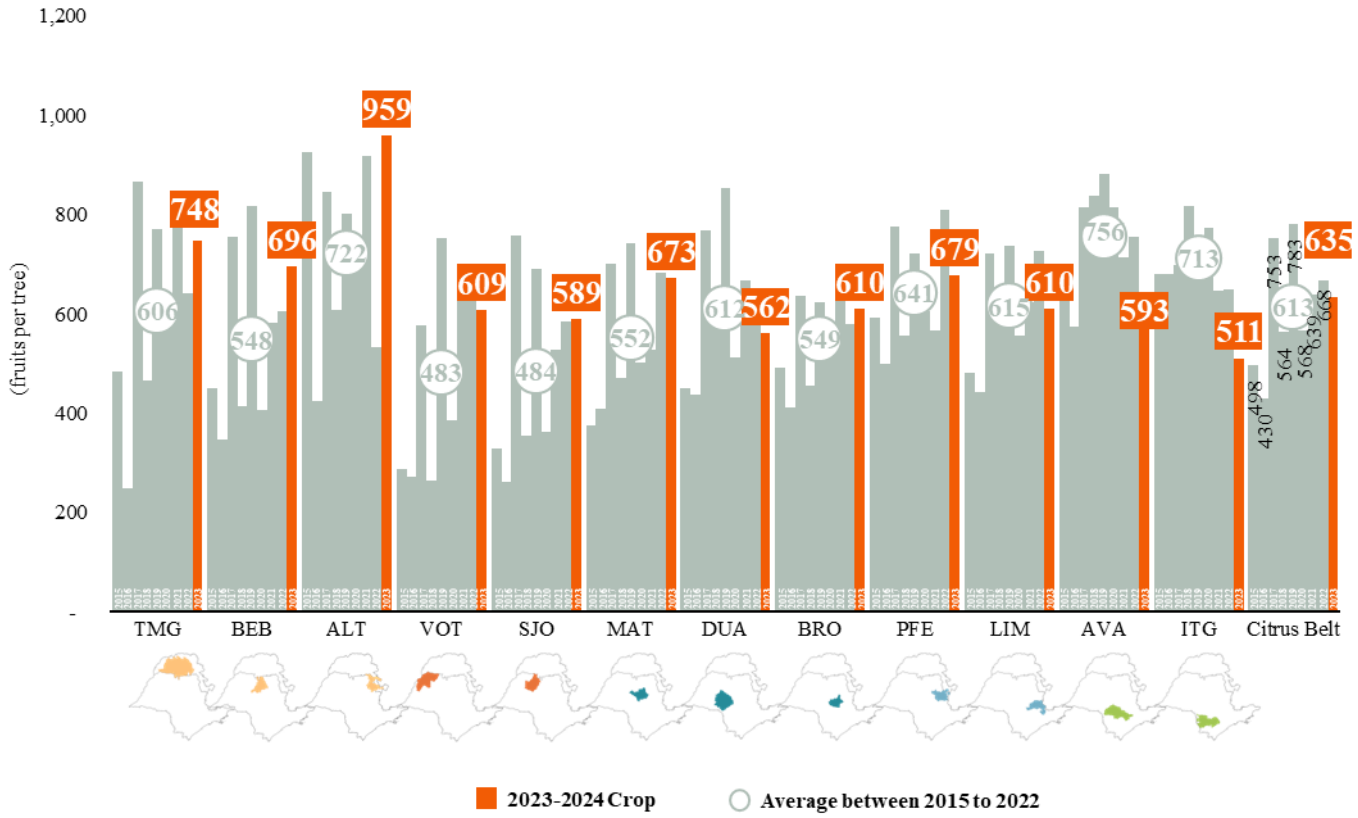
Bearing trees total 169.29 million and occupy an area of 337,091 hectares in this crop season. These figures represent an decrease of 681 thousand trees, equivalent to -0.40% above the 2022 inventory and a decrease in the production area of 2.12%, evidencing the effect of the higher planting density in the last years.

Varieties included in this forecast are present in 97% of the area of orange groves in the citrus belt. Information on bearing trees was obtained from the "Tree inventory of the São Paulo and West-Southwest Minas Gerais citrus belt: Snapshot in March 2023", taken from the 2022 primary base – created by mapping groves from August 16, 2021 to January 28, 2022 – and from counting existing trees in approximately 5% of orange plots from January 10 to March 15, 2023.

2.2 – FRUITS PER TREE

The average number of fruits per tree in April 2023, without considering the drop that occurs throughout the season, is 635, which represents an decrease of 4,9% in relation to the previous crop. The average number of fruits per tree may have a variation of plus or minus 16 units, which is equivalent to ± 2.6% of the average number of fruits per tree at stripping. This figure is within the expected error of 2% to 3% used in sizing the sample.

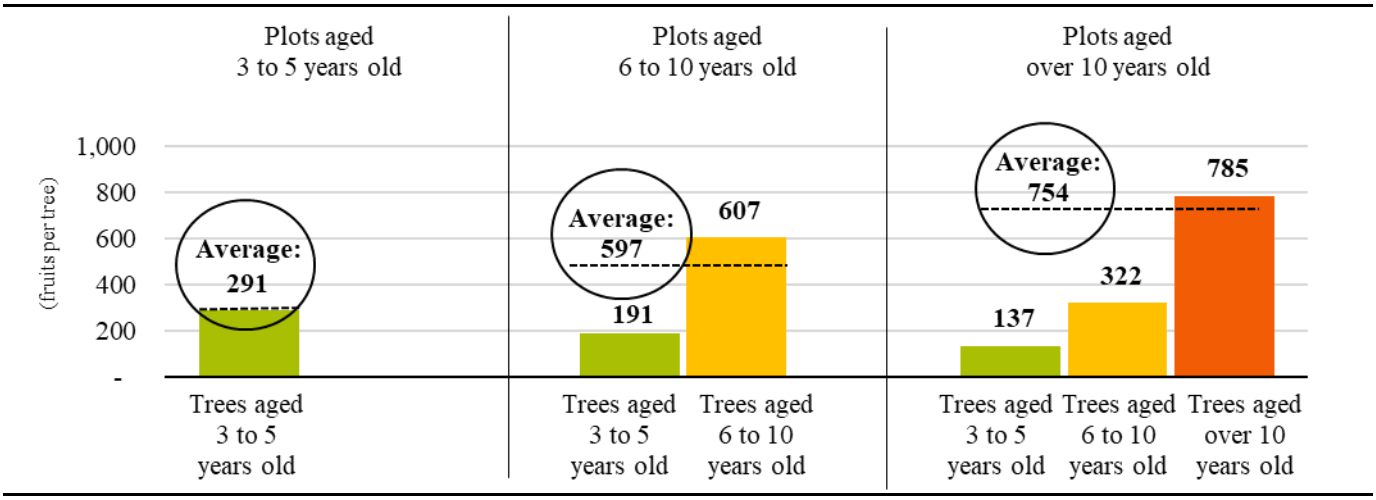
Graph 3 shows the number of fruits per tree at stripping from 2015 to 2023, separately for the 12 regions. Data precision for regions is smaller than that of the general average due to a lower number of samples per stratum. The error in the average number of fruits per tree is ± 9.2% in the Triângulo Mineiro, ± 9.1% in Bebedouro, ± 7.6% in Altinópolis, ± 11% in Votuporanga, ± 9.5%; in São José do Rio Preto, ± 8.8% in Matão, ± 7.1% in Duartina, ± 9.9% in Brotas, ± 8.4% in Porto Ferreira, ± 8.7% in Limeira, ± 7.7% in Avaré, and ± 9.1% in Itapetininga.



Graph 3 - Number of fruits per fruit-stripped tree by region from 2015 to 2023

For the forecast calculation, fruits from the first, second and third blooms were considered in full. A fruit set rate of 50% was applied to fruits from the fourth bloom, since it was a late bloom and because the physiological drop of small and weak fruits had not taken place before stripping ended this year. In the separation of fruits per bloom, off-season fruits were also identified and resulted from late and sporadic flowers from the previous crop season, not accounted for in the current crop forecast.

Three to five-year-old plots present yield of 291 fruits per tree this crop season. For six to 10-year-old plots, an average of 597 fruits per tree is estimated, with 607 fruits per tree for original plantings and 191 fruits per tree for three to five-year-old resets. Plots over 10 years old have an average of 754 fruits per tree and a yield of 785 fruits per tree for original plantings, 322 fruits per tree for six to 10-year-old resets and 137 fruits per tree for three to five-year-old resets. Yield rates are presented in Graph 4.



Ages and planting years: 3 – 5 years (2018 to 2020), 6 – 10 years (2013 to 2017) and over 10 years (2012 and previous years)

Graph 4 - Age-stratified number of fruits per tree in the plot

An average of 828 fruits per tree were counted for the group of earlies Hamlin, Westin and Rubi, 653 fruits per tree for the late season Valencia and Valencia Folha Murcha varieties, 597 fruits per tree for other earlies, 573 per tree for the late Natal variety, and 563 for the mid-season Pera Rio variety.

The method used consists in fruit stripping, that is, the advanced harvest of all fruits in the tree, regardless of the bloom they are from. In this crop season, fruits were stripped from trees from March 13 to April 28, 2022. Fruits harvested were taken to a fruit stripping laboratory in Araraquara, where each sample was separated into the different blooms it was from. Fruits were quantified by automatic counting equipment and then weighed.

Sample size was 1,560 trees selected by a drawing. An initial drawing by the method of stratified random sampling included 1,200 trees distributed proportionally amongst all orange trees in the citrus belt and stratified according to their region, variety and age. An additional drawing included 360 resets of ages lower than the age groups of their groves. These resets correspond to replacements made mainly to offset tree losses caused by citrus greening, citrus blight, gomosis and other diseases. The tree population in this last drawing comprises plots that were counted in full to update the inventory and that meet the stratification criteria.

The stratification factor “region” is comprised of 12 groups encompassing the 320 cities where there are farms with mature orange groves. In addition to the subdivision into the 12 regions, the following charts present the five subdivisions of the factor “variety” and the six subdivisions of the factor “age”. Combinations of these factors result in 360 strata.

Chart 1 - Regions of the citrus belt included in the drawing, by sector

Sector	Region	Abbreviation
North	Triângulo Mineiro	TMG
	Bebedouro	BEB
	Altinópolis	ALT
Northwest	Votuporanga	VOT
	São José do Rio Preto	SJO
Central	Matão	MAT
	Duartina	DUA
	Brotas	BRO
South	Porto Ferreira	PFE
	Limeira	LIM
Southwest	Avaré	AVA
	Itapetininga	ITG

Chart 2 - Variety groups included in the drawing, by maturity time

Maturity time	Variety group
Early	Hamlin, Westin and Rubi
Other early	Valencia Americana, Seleta, Pineapple and Alvorada
Mid-season	Pera Rio
Late	Valencia and Valencia Folha Murcha
	Natal

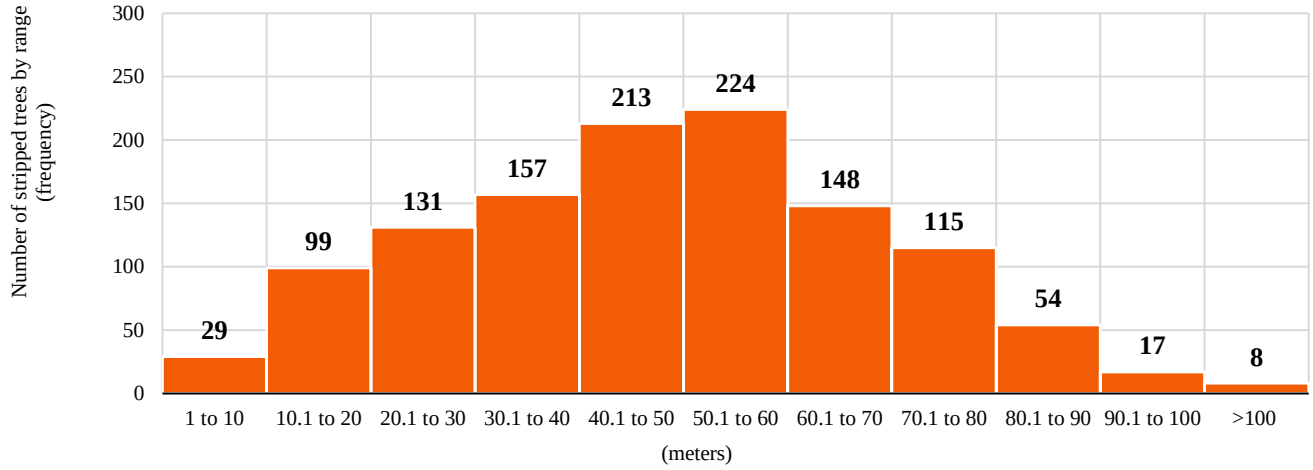
Chart 3 - Age groups from the combined age of plots and age of trees

Age of plots[1]	Age of trees[2]
3 to 5 years	3 to 5 years
6 to 10 years	3 to 5 years
6 to 10 years	6 to 10 years
Over 10 years	3 to 5 years
Over 10 years	6 to 10 years
Over 10 years	Over 10 years

[1] Ages and planting years: 3 to 5 years (2018 to 2020), 6 to 10 years (2013 to 2017) and over 10 years (2012 and previous years)

For the 1,200 trees in the first drawing, the location in the plot of the tree to have fruit stripped from is predetermined and varies every crop season. This makes the selection of the tree unbiased, that is, free from interference of the survey agent. Otherwise, the choice could be skewed towards trees with more or less fruit. For the 2023-2024 crop, the tree in the drawn plot was the one located in the 22rd planting hole in the 13th row. If there was a vacancy or dead tree in that position, or yet a tree of an age different from that of trees originally planted in the plot, the third plant down was selected. Should that situation repeat itself, three more plants down were counted, until a tree of the drawn age was found. If the plot did not have 13 or more planting rows, the counting restarted in the existing rows until number 13 was reached. For the second drawing of 360 resets, the tree was found in the plot after visual aspects were considered, such as trunk circumference and size of canopy.

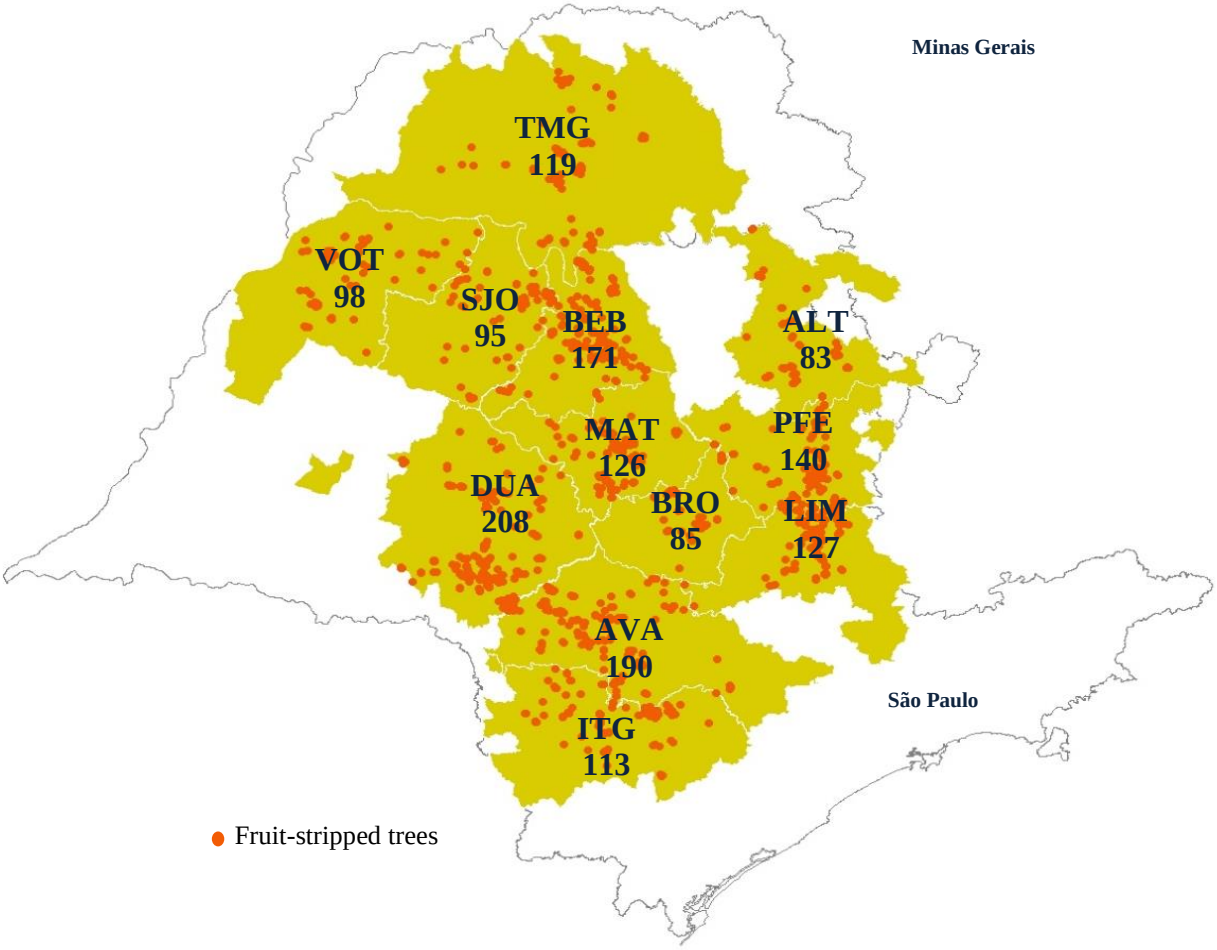
Graph 5 presents the distance (in meters) from the fruit-stripped tree originally planted in the plot to the nearest border of the plot, which shows the majority of classes with similar frequencies, with a central figure between 40 and 60 meters of distance from the fruit-stripped tree to the nearest border.



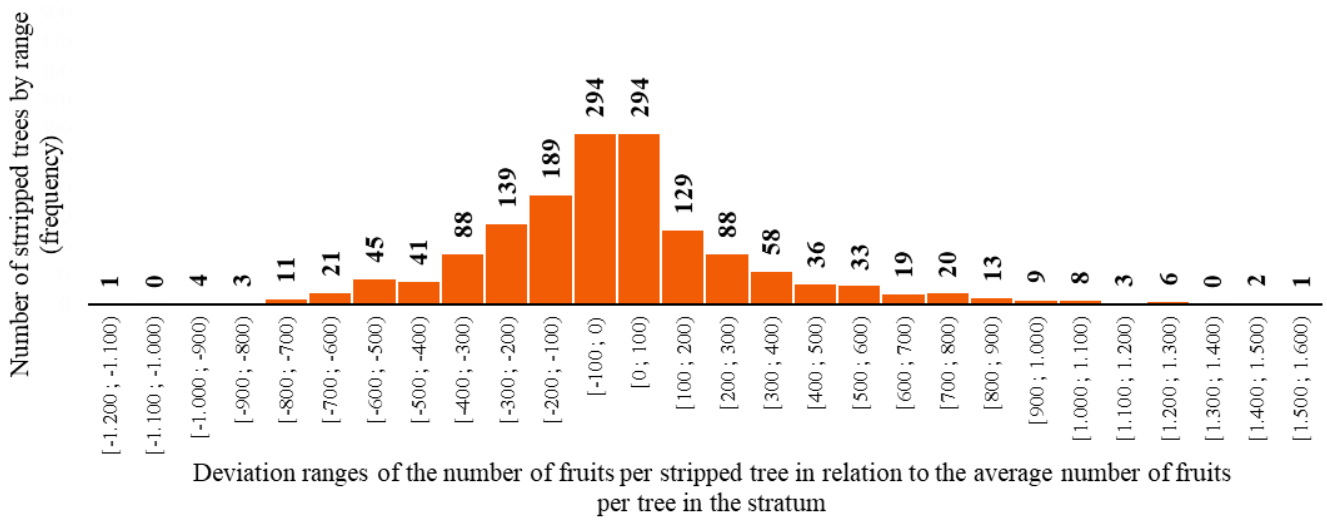
Graph 5 - Histogram of distances from the fruit-stripped tree to the nearest border of the plot

Figure 1 shows the location and number of fruit-stripped trees in each sector of the citrus belt.

Figure 1 - Location and total number of fruit-stripped trees per region

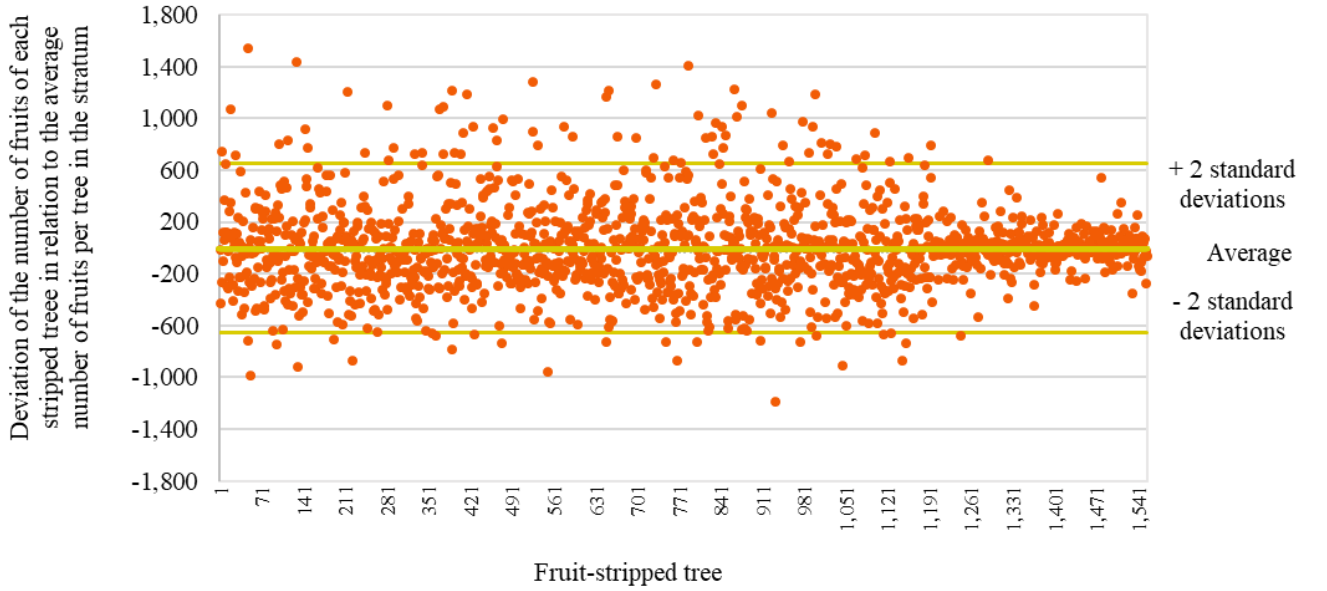


The yield deviation distribution analysis for each fruit-stripped tree in relation to the stratum average shows that sample data are randomly distributed according to a normal distribution, as presented in Graph 6. Out of the total samples, five were discarded upon showing great discrepancy in relation to the others.



Graph 6 - Histogram of deviations of fruits per tree at stripping

Graph 7 shows the dispersion of deviations of each fruit-stripped tree in relation to the stratum average. It is observed that 95% of samples fall within the average (635 fruits) ± 2 standard deviations.



Graph 7 - Deviation on the number of fruits at each stripping in relation to the stratum average

The tree harvested upon permit from citrus growers is indemnified at R$ 50.00 through an online payment system where citrus growers can register and redeem the amount due.

2.3 – DROP RATE – fruit drop index, from tree stripping to final plot harvest

The projected average drop rate is 21.00%, distributed as follows: 10.50% for the early Hamlin, Westin and Rubi varieties, 12.60% for other early varieties, 22.50% for the mid-season Pera Rio variety, 25.50% for the late Valencia and Valencia Folha Murcha varieties, and 26.50% for the late Natal variety. This rate is applied to the number of fruits in the tree in April 2023, when fruits were stripped. The result of this calculation is the estimate of the number of fruits that will be available in the tree at harvest, since part of the oranges in the tree in the beginning of the crop season will fall due to physiological drop, damage caused by machines, pests and diseases, and adverse climatic conditions. As shown in Chart 5, the South sector has the highest drop rate at an average 22.40%, whereas the North sector has the lowest one at 18.20%.

Table 5 – Projected fruit drop rates by sector and variety

Group of varieties	Sector					
	North	Northwest	Central	South	Southwest	Total
	(percentual)	(percentual)	(percentual)	(percentual)	(percentual)	(percentual)
Hamlin, Westin and Rubi……..	9.50	13.80	11.60	12.10	8.50	**10.50**
Other earlies.....	9.00	18.00	13.90	22.50	9.80	**12.60**
Pera Rio.....	19.50	17.50	25.20	23.60	23.90	**22.50**
Valencia and V. Folha Murcha..	22.90	29.50	26.60	26.40	26.00	**25.50**
Natal.....	23.90	28.90	23.10	28.50	29.60	**26.50**
Total.....	**18.20**	**21.00**	**22.20**	**22.40**	**21.70**	**21.00**

Monthly and continuous monitoring carried out by Fundecitrus as of May 2023 in 1,200 orange plots visited up to their complete harvest serves as basis to correct the drop rate projected at the time of this publication and consequently to correct the production estimate as well.

2.4 – FRUITS PER BOX – fruit size, i.e., number of oranges to reach the weight of 40.8 kg (90 lb box) at harvest

The final fruit size projection is 247 fruits per 40.8 kg box (165 grams/5.83 ounces per fruit), namely 304 fruits per box for the group of early varieties comprising Hamlin, Westin and Rubi (134 grams/ 4.73 ounces per fruit), 253 fruits per box for the group of other early varieties (161 grams/5.69 ounces per fruit), 243 fruits per box for the mid-season Pera Rio variety (168 grams/5.92 ounces per fruit), 222 fruits per box for the late Valencia and Valencia Folha Murcha varieties (184 grams/6.48 ounces per fruit), and 227 fruits per box for the late Natal variety (180 grams/6.34 ounces per fruit). Table 6 presents projected fruit sizes by variety and sector.

Table 6 – Projected fruit sizes by sector and variety

Group of varieties	Sector					
	North	Northwest	Central	South	Southwest	Total
	(Fruits estimated per box)	(Fruits estimated per box)	(Fruits estimated per box)	(Fruits estimated per box)	(Fruits estimated per box)	(Fruits estimated per box)
Hamlin, Westin and Rubi……..	306	301	301	309	302	**304**
Other earlies.....	249	250	250	264	269	**253**
Pera Rio.....	240	249	246	251	232	**243**
Valencia and V. Folha Murcha..	214	229	226	230	221	**222**
Natal.....	219	246	235	237	219	**227**
Total.....	**244**	**251**	**249**	**255**	**242**	**247**

The average size of 247 fruits per box is equivalent to oranges weighing approximately 165 grams (5.82 oz) at harvest. The final fruit size was estimated by a regression model that considered the final fruit size (fruits per box at harvest) as the dependent variable, and the number of fruits per tree counted at stripping, the initial fruit size (fruits per box at stripping), the sum of the production percentages of the first and second blooms in relation to the total production and the rainfall accumulated from May to July as independent variables. Data from eleven crops, 2011-2012 to 2022-2023, were used in the regression and are presented in Table 6. Data from the 2021-2022 crop were not used because that was a period of totally atypical climate

conditions, with the worst drought in almost a century and high-intensity frosts. The result obtained shows an adjusted R^2 of 0.90. This means that the four independent variables together explain 90% of the variation in the final fruit size (fruits per box at harvest), which shows how important these variables are for the final fruit size. The comparison between the final fruit size estimated by this model and the final fruit size observed in these eleven crops presents an average absolute error of 2.6%.

Data relative to final fruit size (fruits per box at harvest), number of fruits per tree counted at stripping, initial fruit size (fruits per box at stripping), the sum of the production percentages from the first and second blooms in relation to the total production for the series from 2011-2012 to 2014-2015 were provided by orange juice companies associated to Fundecitrus – Citrosuco, Cutrale and Louis Dreyfus –, which separately have estimated the production for the citrus region since 1988, with the use of objective methodology. Data were supplied individually and under a formal confidentiality agreement to an independent consulting firm for the determination of the average. Individual data supplied by each company were kept confidential. Data relative to the 2015-2016 to 2022-2023 crops come from results of estimates developed by Fundecitrus. Data on rainfall accumulated from May to July were supplied by Somar Meteorologia/Climatempo.

Data used in the model to estimate the final fruit size in this crop comprise figures from the 2023 stripping and the rainfall from May to July 2023 in a volume equivalent to 150 millimeters. This size (248) obtained in the first regression was corrected by the second regression that used the observed size as the dependent variable and the estimated size as the independent variable, resulting in a projection of 247 fruits per box.

Table 7 – Data for the 2011-2012 crop to the 2022-2023 crop used to estimate the final fruit size in the 2023-2024 crop

Crop	Fruits per tree at stripping	Initial fruit size at stripping	Sum of productions from first and second blooms	Accumulated rainfall from May to July	Final fruit size observed at harvest	Final fruit size estimated by the first regression	Error	Absolute error
	(number)	(fruits/box)	(%)	(millimeters)	(fruits/box)	(fruits/box)	(%)	(%)
2011/12....	859	401	96%	116	269	265	-1%	1,5%
2012/13....	764	439	95%	268	250	239	-4%	4,3%
2013/14....	515	338	87%	247	224	218	-3%	2,7%
2014/15....	646	373	92%	102	256	248	-3%	3,1%
2015/16....	498	391	90%	204	226	233	3%	3,2%
2016/17....	430	358	90%	214	222	224	1%	0,7%
2017/18....	753	393	91%	184	246	252	3%	2,6%
2018/19....	564	446	82%	36	259	252	-3%	2,9%
2019/20....	783	411	94%	95	261	266	2%	1,8%
2020/21....	568	511	85%	96	258	252	-3%	2,5%
2022/23....	668	462	86%	59	256	265	3%	3,3%
2023/24....	635	452	82%	150	(X)	248	(X)	(X)

Sources: Fundecitrus (2015-2016 crop to 2023-2024 crop), CitrusBr (2008-2009 crop to 2014-2015 crop), Somar Meteorologia/Climatempo
(X) Not applicable

The result of the equation used in the crop estimate is corrected by the application of a correction factor. That is necessary because of variables not accounted for in the calculations, such as harvested fruits that wind up not being used, diverse planting densities that are not considered in the stratification of groves, and losses of trees throughout the crop season caused by eradications, abandonments or deaths. The correction factor of 0.10 applied in this crop is the same used since the 2017-2018 crop, which represents the average of the indexes for the 2015-2016 and 2016-2017 crops estimated by Fundecitrus.

3 – TABLES OF DATA

The following tables present the 2023-2024 orange crop forecast per sector, age, bloom and variety. The margin of error of the production estimate in the strata is higher than that of the production estimate in the citrus belt as a whole. Possible subsequent variations in fruit size and fruit drop rate may change the forecast and will be accounted for throughout the crop season by ongoing field monitoring for production estimate updates.

Table 8 - 2023-2024 Orange crop forecast by sector

Sector	Mature groves area	Average density[1] of mature groves	Bearing trees	Fruit per tree at stripping[2]	2023-2024 Orange crop forecast		
					Per tree	Per hectare	Total
	(hectares)	(trees/ hectare)	(1,000 trees)	(number)	(boxes/ tree)	(boxes/ hectare)	(1,000,000 boxes)
North.....	80,891	488	38,932.43	746	2.26	1,088	88.01
Northwest.....	31,350	492	14,998.59	597	1.69	808	25.33
Central.....	91,182	536	47,676.70	603	1.70	887	80.90
South.....	59,913	510	29,452.08	648	1.77	872	52.23
Southwest.....	73,755	536	38,231.35	566	1.64	852	62.87
Total.....	**337,091**	**516**	**169,291.15**	**635**	**1.83**	**918**	**309.34**

[1] Calculation considers the total number of trees in the plot, that is, bearing and non-bearing trees (2021 and 2022 resets)
[2] Weighted average per total stratum fruit

Table 9 - 2023-2024 Orange crop forecast by tree age group (continues below)

Age of plots	Mature groves area	Average density[1] of mature groves	Bearing trees by age group				Fruit per tree at stripping by age group of trees[2]			
			3 – 5 years	6 – 10 years	Over 10 years	Total	3 – 5 years	6 – 10 years	Over 10 years	Total
	(hectares)	(trees/ hectare)	(1,000 trees)	(1,000 trees)	(1,000 trees)	(1,000 trees)	(fruit/ tree)	(fruit/ tree)	(fruit/ tree)	(fruit/ tree)
3 – 5 years.....	56,425	598	31,502.50	-	-	31,502.50	**291**	-	-	291
6 – 10 years.....	58,397	623	917.49	34,532.98	-	35,450.47	191	**607**	-	597
Over 10 years…...	222,269	467	1,795.49	4,361.84	96,180.85	102,338.18	137	322	**785**	754
Total.....	**337,091**	**516**	**34,215.48**	**38,894.82**	**96,180.85**	**169,291.15**	**280**	**575**	**785**	**635**

[1] Calculation considers the total number of trees in the plot, that is, bearing and non-bearing trees (2021 and 2022 resets)
[2] Weighted average per total stratum fruit

Table 9 – 2023-2024 Orange crop forecast by tree age group (continued)

Plots age	2023-2024 Orange crop forecast by tree age group				2023-2024 Orange crop forecast by tree age group			
	3 – 5 years	6 – 10 years	Over 10 years	Total	3 – 5 years	6 – 10 years	Over 10 years	Total
	(boxes/ tree)	(boxes/ tree)	(boxes/ tree)	(boxes/ tree)	(1,000,000 boxes)	(1,000,000 boxes)	(1,000,000 boxes)	(1,000,000 boxes)
3 – 5 years.....	0.84	-	-	0.84	**26.56**	-	-	26.56
6 – 10 years.....	0.56	1.75	-	1.72	0.51	**60.52**	-	61.03
Over 10 years…...	0.39	0.92	2.26	2.17	0.70	4.02	**217.03**	221.75
Total.....	**0.81**	**1.66**	**2.26**	**1.83**	**27.77**	**64.54**	**217.03**	**309.34**

[1] Calculation considers the total number of trees in the plot, that is, bearing and non-bearing trees (2021 and 2022 resets)

Table 10 - 2023-2024 Orange crop forecast by bloom

Bloom	2023-2024 Orange crop forecast	Percentage of the orange crop forecast by bloom
	(1,000,000 boxes)	(percentage)
1st.....	111.83	36.2%
2nd	142.56	46.1%
3rd.....	50.43	16.3%
4th	4.52	1.5%
Total.....	**309.34**	**100.00%**

Table 11 - 2023-2024 Orange crop forecast in percentage of bloom by region

Bloom	North[1]				Northwest[2]			Central[3]				South[4]			Sothwest[5]			Total
	TMG	BEB	ALT	**AVE**[6]	VOT	SJO	**AVE**[6]	MAT	DUA	BRO	**AVE**[6]	PFE	LIM	**AVE**[6]	AVA	ITG	**AVE**[6]	
	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)
1st.....	37.5	42.8	10.7	**35.9**	64.3	24.6	**40.3**	33.0	47.2	13.5	**38.5**	17.3	39.3	**26.7**	40.9	43.8	**41.8**	**36.2**
2nd.....	54.8	40.1	68.2	**49.3**	18.4	63.7	**45.8**	52.7	29.8	62.0	**41.6**	59.4	42.2	**52.0**	39.9	43.2	**40.9**	**46.1**
3rd.....	6.5	16.1	19.1	**13.6**	17.2	11.5	**13.8**	12.7	22.4	23.5	**18.9**	21.0	15.8	**18.8**	18.6	8.0	**15.4**	**16.3**
4th.....	1.2	1.0	2.0	**1.2**	0.1	0.2	**0.1**	1.6	0.6	1.0	**1.0**	2.4	2.7	**2.5**	0.6	4.9	**1.9**	**1.5**

1 North: TMG – Triângulo Mineiro, BEB – Bebedouro, ALT – Altinópolis
2 Northwest: VOT – Votuporanga, SJO – São José do Rio Preto
3 Central: MAT – Matão, DUA – Duartina, BRO – Brotas
4 South: PFE – Porto Ferreira, LIM – Limeira
5 Southwest: AVA – Avaré, ITG – Itapetininga
6 AVE – Weighted average per total stratum fruit

Table 12 - 2023-2024 Orange crop forecast and its components by variety group

Variety group	Mature groves area	Average density[1] of mature groves	Components of May/2023 forecast				2023-2024 Orange crop forecast		
			Bearing trees	Fruit per tree at stripping[2]	Fruit estimated per box	Estimated drop rate	Per tree	Per hectare	Total
	(hectares)	(trees/ hectare)	(1,000 trees)	(number)	(number)	(%)	(boxes/ tree)	(boxes/ hectare)	(1,000,000 boxes)
Early:									
Hamlin, Westin and Rubi.....	55,459	473	25,716.04	828	304	10.50	2.18	1,012	56.11
Other early:									
Valencia Americana, Seleta, Pineapple and Alvorada……	18,763	552	9,866.33	597	253	12.60	1.85	971	18.22
Mid-season:									
Pera Rio.....	116,678	545	61,508.67	563	243	22.50	1.61	848	98.95
Late:									
Valencia and VFolha Murcha[3]	108,514	503	53,648.92	653	222	25.50	1.96	970	105.23
Natal.....	37,677	507	18,551.19	573	227	26.50	1.66	818	30.83
Total.....	**337,091**	**516**	**169,291.15**	**635**	**247**	**21.00**	**1.83**	**918**	**309.34**

(X) Not applicable
1 Calculation considers the total number of trees in the plot, that is, bearing and non-bearing trees (2021 and 2022 resets)
2 Weighted average per total stratum fruit
3 V.Folha Murcha – Valencia Folha Murcha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