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Survey of sour passion fruit cultivars commercialized in Brazil

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Abstract. Among the cultures that make up fruit growing, passiculture stands out, through the socioeconomic importance that is used to it. Due to its importance, research is aimed at improving passion fruit in order to increase the productive potential of orchards by using more productive cultivars that adapt to the various growing regions. Based on these advances, the present study aims to characterize the main yellow passion fruit cultivars recorded and marketed. Among the characteristics of the new cultivars, the resistance of the main diseases of the crop, cultivars developed to meet the demand of the industry, as well as the increase in pulp yield, stand out. Therefore, it is concluded that by incorporating new vegetative materials into the market, there is an appreciation of the fruit, which can be classified already at the time of selection of the cultivar as to its aptitude. In the same way, there is an increase in productivity when using appropriate management techniques in line with cultivars adapted to the most distinct environmental conditions.
Keywords: *Passiflora edulis*, ecosystem, productivity, registration.

Introduction

Fruit growing is one of the most important segments of Brazilian agriculture, being responsible for numerous crops of economic interest, among them, that of yellow passion fruit (*Passiflora edulis* Sims) (Souza et al., 2020). Passiculture is extremely relevant in the national scenario, due to the socioeconomic importance that is used to it, being destined both for in natura and processed trade, thus becoming the country the main producer and consumer (Macedo et al., 2019; Jesus et al., 2020).

Rodrigues et al. (2020) mention that the edaphoclimatic conditions of Brazil favor the dissemination and development of culture, and, due to adaptation to environmental conditions, the country has more than 140 native species. Although Brazil is one of the centers of genetic diversity of passion fruit, few varieties are commercially exploited, with yellow passion fruit accounting for about 95% of planted areas (Jesus et al., 2018).

In 2020, the areas destined to the passion fruit plantation totaled 46,530 hectares, resulting in an average yield of 14.86 t ha^{-1}, with the South, Midwest and Southeast regions being the most productive, with 18.83 t ha^{-1}, 17.56 t ha^{-1} and 17.19 t ha^{-1} respectively (IBGE, 2021). Also according to IBGE estimates, in Acre, only 0.2% of the areas destined to temporary or permanent crop crops are occupied with the crop, resulting in yield of only 8.87 t ha^{-1}.

It is emphasized that, although the national income meets the required demand, the productive potential of the crop, according to Grisi et al. (2021) is limited by edaphoclimatic factors, inadequate management, and use of vegetative materials of low agronomic performance. The authors also mention that in the first year of cultivation passion fruit can produce up to 40 t ha^{-1}, provided that improved cultivars and appropriate cultivation techniques are used. Viana et al. (2016) state that the improvement of passion fruit provides increased productivity by incorporating into the market cultivars with higher yield, superior fruit quality and resistant to diseases.

As the need arises for more productive cultivars that adapt to several regions, breeding programs such as EMBRAPA Cerrados launch on

the market cultivars with superior, more productive characteristics, with higher pulp yield and tolerant the main diseases of passion fruit (Zacharias et al., 2020). According to the National Register of Cultivars, from the first record dated in 1999 to the present year 2021, there are 30 yellow passion fruit cultivars and 8 registered parental lines (Brasil, 2021a).

Thus, through the importance of the crop and the amplitude of cultivars implemented in the market, the present study aims to characterize the main yellow passion fruit cultivars recorded and marketed.

Cultivars

Yellow

The cultivar Amarelo is the first registered in the RNC, and, due to this, there is little information regarding its destination, regions of better adaptation, tolerance or resistance to diseases and pests, as well as pulp quality and juice yield. Meletti et al. (2005) report on the difficulty of obtaining information about the material, although commercialized, stating that the available information is generic. As a characteristic, its fruit has gold yellow color, elongated round shape and physical aspects, it has a length ranging from 6 cm to 9 cm and diameter from 5 cm to 8 cm, and can reach an average mass of between 100 g to 140 g (Feltrin, 2021a).

IAC 273 - Monte Alegre

Developed by the Agronomic Institute (IAC) and belonging to a series of material called "IAC Series 270" whose purpose was the incorporation of cultivars with higher fruit quality and productivity, IAC 273 stands out for meeting the demand of fruits for the in natura segment, through the homogeneity acquired in the orchards, providing larger fruits (Meletti, 2011).

As a characteristic, the plant has vigorous growth with beginning of production between 8 and 9 months, which classifies it as non-early. Although late, flowering is abundant and when artificial pollination is performed, fruiting is continuous, resulting in high productivity, between 40 and 50 t ha^{-1} per year (Meletti, 2001). The same authors report that the fruits are yellow, with length and diameter on average of 8.8 cm and 7.5 cm, respectively, mass ranging from 220 to 250 g, thick bark from 0.7 cm to 1 cm which facilitates transport (Fredo et al., 2021).

The pulp is yellow-orange with soluble solids content from 13 ºBrix to 14 ºBrix and can reach up to 17 ºBrix and pulp yield greater than 46% when artificial pollination was performed (Meletti, 2001).

IAC 275 - Wonder

Resulting from the "IAC Series 270", the cultivar IAC 275 was developed to meet not only the demand of in natura trade, but the industry, due to the high gains attributed with pulp processing (Meletti, 2001). Meletti (2009) reports that before the incorporation of this new material, the juice agroindustry depended exclusively on surpluses related to the fresh fruit market, without the standardization of the quality of what was processed, in addition to the low yield of the pulp commonly observed.

In view of the facts mentioned, the cultivar IAC 275 stood out within the materials that were being developed, being the most commercialized after inclusion in the market, because it has vigorous growth, with high precocity, and production can start from 6 to 7 months after planting (Meletti, 2001).

Dias et al. (2017) mention that the yield of this cultivar is around 40 t ha^{-1}, its fruits are of ovais, yellowish coloration, length of 8.29 cm and diameter 6.89 cm, with average fruit mass of 120 g, pulp yield higher than 28 t ha-1 and pulp yield of 60%, and these characteristics are appreciated in the industry. The authors observed that the pulp presents soluble solids contents of 14 ºBrix, titratable acidity of 8.17% and pH 2.79.

IAC 277 - Jewelry

Also developed to meet the demand of the fresh market, the cultivar IAC 277 presents attributes similar to IAC 273 implying difficulty in differentiation by producers (Meletti, 2001). The authors also point out that although similarity, when using IAC 277, there is a drop of up to 10% productivity compared to IAC 273 due to fruit characteristics and environmental conditions during peak production makes it susceptibility to anthracnose (*Colletotrichum gloeosporioides*).

The cultivar has vigorous growth, with production between 7 to 8 months after the implementation of the orchard, and abundant flowering, which, by inducing pollination artificially, benefits the increase in productivity, reaching a variation of 40 to 50 t ha^{-1} (Meletti, 2001). Another advantage tied to productivity is the destination of the fruit, where the ones with the highest mass are destined for table consumption and the other ones meet the agro-industrial demand.

The fruits are of formatted ovais, yellow in color, with a length of 9.6 cm and 8.5 cm in diameter, a mass ranging from 200 to 240 g (Rosa et al., 2020). As a differentiation of the cultivar, the thickness of the bark is from 5 mm to 6 mm, which provides a higher proportion of the pulp in relation to the fruit mass, reaching 48% or higher of this percentage (Ferreira et al., 2016). The pulp is orange yellow, with soluble solids contents between 13 to 15 ºBrix, titratable acidity 4.4 and pH 3.03 (Fredo et al., 2021).

IAC Paulista

The cultivar IAC Paulista is the result of several cycles of mass selection of the crossing between the cultivar IAC 277 and the purple passion fruit, which resulted in fruits of purple-red color, with low acidity and greater resistance to wilting after harvest (Meletti et al., 2006). And, according to the

same authors, because it came from a native genitor, it better adapts the regions of mild climate tolerating the incidence of cold winds, and in tropical climate places, excess heat at some times of the year can have a negative influence on pollination, through the possible sterility that pollen grain can suffer.

With plants of median size, precocity similar to IAC 277 (7 to 8 months) is observed, although it presents medium-mediated flowering and consequently, even when submitted to artificial pollination, it holds low productivity in comparison the other IAC (25 t ha^{-1}) even the pulp reaching up to 50% of the fruit mass, and, due to this, it is intended for production for in natura consumption, mainly due to the exuberance and attractiveness that the fruit exerts in relation to those of yellow bark (Meletti & Capanema, 2014).

The fruits of medium size, when ripe in addition to purple-red color, they have white spots, with shell thickness classified as thin, length and diameter of 7.6 cm and 7 cm respectively and mass of 100 g to 160 g. Orange yellow pulp, with soluble solids between 13 ºBrix and 18 ºBrix, titratable acidity of 2.4% and pH of 2.78 (Meletti et al., 2006).

BRS GA1

Formerly called BRS Gigante Amarelo, currently cultivar BRS GA1, it is a simple intravarietal hybrid, resulting from population improvement by recurrent selections, derived from the southern brazil and redondão selection matrices (Abreu et al., 2009). Araújo Filho et al. (2019) mention that, among the vegetative materials marketed, there is preference of producers regarding this cultivar, being therefore well disseminated throughout the national territory, except in places subject to frost.

Its flowering occurs constantly with a significant increase in the dry periods and, associated with this, high productivity stands out, in which in the first can be up to 42 t ha^{-1} even with incidence of virus, subsequent reduction in the second year, being around 20 t ha-1 to 25 t ha^{-1}, when the management methods required by the crop are implemented (EMBRAPA, 2014). In Acre, a state that the cultivar is already recommended, this productivity is higher than 47 t ha^{-1} and 30 t ha^{-1} in the first and second year, respectively, even with low planting density (Andrade Neto et al., 2015).

Of the desirable characteristics, good tolerance to anthracnose and bacteriosis are attractive conditions for the implementation of new orchards, although it is necessary to use integrated disease management techniques to avoid verrugosis, virus and diseases caused by soil pathogens through the susceptibility that the crop has (Meletti, 2011).

The fruits are yellow, oblong in shape, length from 9.6 cm to 10.8 cm, diameter between 7.8 cm to 8.9 cm, with mass ranging from 120 g to 350 g and bark thickness from 4.5 mm to 6 mm (EMBRAPA, 2014; Cunha et al., 2016). The pulp, with strong yellow coloration, presents yield around 40%, with soluble solids contents of 13 °Brix at 15 °Brix and titratable acidity of 4.5% (Andrade Neto et al., 2015).

BRS OV1

Resulting from population improvement by recurrent selection, with the obtaining and evaluation of intraspecific hybrids, whose populations sought to increase variability, using the matrices (cultivar South Brazil Marília x Selection *of Passiflora edulis* Roxo) F1 x matrix derived from GA-2 to obtain the cultivar BRS OV1, formerly brs Ouro Vermelho (EMBRAPA, 2008).

With a recommendation for cultivation for almost all national territory, except for sites subject to frost, BRS OV1 has productivity already in the first cycle around 40 t ha^{-1} with the use only of natural pollination, but, with high productive potential, all management methods already consolidated for culture are used, since flowering occurs throughout the year and is intensified in dry periods (EMBRAPA, 2008). The cultivar is tolerant to viruses and other florid diseases and may be tolerant to diseases caused by soil pathogens (Cavichioli et al., 2014).

Because it comes from a genitor that is characterized by the purple color of its bark, BRS OV1 can have up to 20% of fruits with red or purplish coloration, of the more, yellowish, destined for industry and consumption in natura (EMBRAPA, 2008). The fruit mass varies from 120 to 350 g, they are round, homogeneous, with an average length and diameter of 9.9 cm and 8.8 cm, respectively, peel thickness around 6.7 mm which guarantees greater resistance to transport and shelf time (Cobra et al., 2015). The pulp of high yield is of strong yellow coloration, with yield of 34% to 50%, with soluble solids from 13 ºBrix to 15 ºBrix, titratable acidity of 8.81% and pH on average of 2.8 (Ferreira et al., 2016; Dias et al., 2017).

BRS SC1

Obtained through population improvement by recurrent selection, obtaining and evaluating intraspecific hybrids, the cultivar BRS SC1 formerly called BRS Sol do Cerrado is the result of the matrices of GA-2 and MA (matrix derived from the Redondão selection) (EMBRAPA, 2014b). The cultivar has as an advantage the tolerance for anthracnose, bacteriosis and virus although susceptibility to diseases caused by soil pathogens (Cavichioli et al., 2014). Cohen et al. (2008) highlight the high productivity and resistance to transport as desirable characteristics, commonly obtained when using such material.

Regarding productivity, because it is flowering continues, for the region of the Federal District, place of development of the cultivar, it is estimated for the first year of cultivation values higher than 40 t ha^{-1}, this, without adopting the artificial pollination method, highly disseminated for the crop, and in the second year can obtain up to 25

t ha^{-1} depending on the management methods (Cohen et al., 2008). It is observed that it is characteristic of the cultivar high productivity, such as in Acre, for the first year when implementing all recommended techniques for culture, it is reached 41 t ha^{-1}, reducing to 27 t ha^{-1} in the second (Andrade Neto et al., 2015b).

Its fruits are large and can be destined for industry and table, oblong shape, bright yellow color, with mass ranging from 150 g to 350 g, length from 7.7 cm to 9.4 cm, diameter from 7.0 cm to 8.4 cm and thickness of the bark on average of 6.9 mm which ensures resistance to transport, in addition to longer shelf life (Krause et al., 2012; Tupinambá et al., 2012). The pulp, of strong yellow coloration, presents a higher amount of vitamin C, soluble solids from 13 ºBrix to 14 ºBrix, acidity and pH on average 4.5% and 2.9%, with pulp yield ranging from 35% to 40% depending mainly on the performance of artificial pollination (EMBRAPA, 2014b; Andrade Neto et al., 2015b).

FB 200 Yellow Master

The hybrid FB 200 presents as main characteristics the vigor of the plant, as well as the size and shape of the fruit, being classified as oval, uniform, with an average mass of 240 g, destined to the fresh and industrial market for achieving productivity of up to 50 t ha^{-1} when culture management was implemented (Meletti et al., 2012). According to Valle et al. (2018), on average, length of 10.26 cm and diameter of 9.19 cm are obtained, with a shell thickness of 7.2 mm, which guarantees greater resistance in transport. The pulp yields 36%, orange yellow coloration and soluble solids of 13 ºBrix (Brasil, 2021b).

FB 300 Araguari

With main destination in the industrial market, the cultivar FB 300 is the result of 25 years of genetic improvement and stands out through rusticity and its productive potential of up to 50 t ha^{-1} when recommended management methods for the crop are applied (Brasil, 2021c). The fruits are of size, shape, and color uneven, and may have yellow to purple color with white spots, length from 7.7 cm to 9.3 cm, diameter ranging from 6.6 cm to 8.7 cm and average mass of 180 g (Botelho et al., 2017). The pulp, orange yellow, has juice yield around 42% with soluble solids on average 15 ºBrix (Brasil, 2021c).

Ground

Adapted to high temperatures, with cultivation indicated for tropical and subtropical regions, the cultivar Sol is an F1 hybrid, which has as characteristic fruits identical to the selection genotype, in addition to uniformity of the orchard. The aim of incorporating this new cultivar was to achieve quality standards and production similar to or higher than FB 200, FB 300 and Sol do Cerrado, which were already commercially consolidated in previous years (Feltrin, 2010).

The period that comprises the implementation of the orchard until harvest is around 5 to 7 months and can obtain productivity of up to 50 t ha^{-1}, which gives it a high productive potential. Its fruits are large and uniform, of round oval shape, bright yellow color, length and diameter of 10 cm and 9 cm respectively, with mass ranging from 300 g to 350 g. The fruit has good acceptance in the fresh market through the high yield of juice and higher total acidity of the pulp (Feltrin, 2021b).

BRS RC

Obtained based on population improvement through recurrent selections, obtaining and evaluating intra- and interspecific hybrids, with the first crosses initiated in 1998, using commercial and wild accesses of passion fruit, resulting in the hybrid F1 BRS RC formerly called BRS Rubi cerrado, obtained with the crossing between the matrices CPAC-MJ-M-08 and CPAC-MJ-M-06 (EMBRAPA, 2014c).

Planting can occur throughout the year in places with an irrigation system implemented, except for those subject to frost and soils subject to soaking, and, in regions with well-defined dry and rainy seasons, planting at the beginning of the drought is recommended. When the management techniques are implemented, productivity of more than 50 t ha^{-1} can be obtained in the first year of cultivation (EMBRAPA, 2014c). Resistance to viruses, bacteriosis, anthracnose and superior verrugosis among cultivars already commercialized (EMBRAPA, 2021) stands out.

It produces rounded fruits that predominate the red or purplish color when ripe, with a mass from 120 g to 300 g, peel thickness from 4.4 mm to 6.2 mm, which gives it resistance to transport, length from 8.8 cm to 10 cm and diameter from 7.4 cm to 8.2 cm (Botelho et al., 2017). The strong yellow pulp, indicative of high concentrations of vitamin C, with soluble solids from 13 ºBrix to 15° Brix, juice yield around 35%, being therefore destined for industry and in natura consumption (Agrocinco, 2021).

SCS437 Catherine

Resulting from more than twenty selection cycles, the cultivar SCS437 Catarina was developed through the partnership between the Agricultural Research And Rural Extension Company of Santa Catarina (EPAGRE), with rural extensionists and passion fruit producers from the south-santa catarina coast region (Petry et al., 2019). The authors mention that their cultivation is destined to the southern territory of Brazil, except in places of occurrence of frosts.

Of interest to the production chain, the: tolerance to anthracnose and bacteriosis, although susceptibility to the virus of fruit hardening; resistance to transport; and, when submitted to fertigation, flowering is more intense, which provides high productivity, and can obtain up to 90 t ha^{-1} in the first year (Schneider, 2021).

The fruits are classified as large and oval, of excellent visual aspect, with yellow peel, thickness greater than 7 mm, length ranging from 12 cm to 14.5 cm, diameter from 7.8 cm to 10.2 cm and average mass between 160 g to 430 g (Isla, 2021a). The pulp, orange in color, has values for soluble solids ranging from 9 ºBrix to 14.5 ºBrix, with acidity between 1.8% to 5.4%, with pulp yield potential up to 50% (Petry et al., 2019).

UENF Golden River

Derived from the interpopulation recurrent selection carried out over three cycles, the cultivar UENF Rio Dourado is destined for the North and Northwest regions of the state of Rio de Janeiro, presenting high performance of agronomic and morphological characteristics, and in some aspects similar to other cultivars marketed.

The estimated productivity is 25 t ha-1 when used only of natural pollination (Rio Norte, 2021). It presents yellowish fruits, average mass of 250 g, length of 8.4 cm and diameter of 7.6 cm, peel thickness of 7.1 mm, with pulp yield up to 41% and as chemical attributes, soluble solids of 13.5 ºBrix and pH 3.2 (VIANA et al., 2016).

Solar

In order to indicate new vegetative material with agronomic characteristics higher than those already commercialized, researchers from the State University of Mato Grosso (Unemat), with the financial assistance of the Research Support Foundation of the State of Mato Grosso (Fapemat) and the National Council for Scientific and Technological Development (CNPq) through studies over twelve years, implemented the cultivar Solar (Maia, 2021).

As a differential, the plant is vigorous with deep root system, high fruit collection, cycle of 180 days, and can be implemented throughout the year in the North, Northeast and Midwest regions, with limitation only for the South and Southeast, in these, only during the summer period. Leaf disease tolerance and resistance attributed to anthracnose, verrugosis and bacteriosis stand out. The fruit, destined to the fresh market is oval in shape, bright yellow color, smooth texture peel, with length and diameter of 10 cm and 8 cm respectively, average mass of 250 g and, as characteristic of the pulp, high content of soluble solids (ºBrix) (Feltrin, 2021c)

Round Yellow

Characterized by excellent production for 2 to 3 years, redondo amarelo cultivar presents double aptitude, destined for in natura and medicinal consumption, with recommendations for cultivation in regions of warm to mild temperature (ISLA, 2021b). The harvest begins between 7 and 8 months after sowing, the fruits, of oblong shape, with yellow peel coloration, on average, mass of 150 g, length of 7.6 cm, diameter of 6.6 cm, peel thickness 6.4 mm, soluble solids 12.8 ºBrix, acidity 3.8% and pH 3.0 (SANTOS et al., 2017).

Final considerations

The incorporation of new cultivars to the market provides appreciation of the fruit, which can be classified already at the time of selection of the cultivar as to its aptitude. Similarly, more productive cultivars with better pulp yield performance have already been developed.

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