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Citricultor

Fundecitrus
SCIENCE AND SUSTAINABILITY
IN CITRICULTURE



International network benefits **citriculture**

FUNDECITRUS, FAPESP, AND ESALQ/USP CREATE THE LARGEST CITRUS RESEARCH
CENTER IN THE WORLD TO PROMOTE RESEARCH, KNOWLEDGE DISSEMINATION,
AND TECHNOLOGY TRANSFER TO FIGHT AGAINST GREENING

The value of a leader *and their legacy*

A leader can be described as a figure at the forefront of a group, who leads, based on relevant motivations or foresight, towards certain common goals, altering the status quo and leaving a legacy which entails work and inspiration. They are always capable of causing an impact.

Humanity has had its leaders, such as Winston Churchill, the Prime Minister of the United Kingdom, who led the Allies against the Axis, freeing the West from fascism and Nazism. Liberal democracy owes a lot to him. America also had its leaders. Brazil had its leaders. Fundecitrus had its leaders.

Note the choice of the verb tense "had" in the past. And why is it? Because leadership can only be endorsed by time. Not all Prime Ministers are leaders. Not all Presidents are leaders in the sense of causing positive impact. A leader cannot be mistaken for a boss, nor for a genius. Leaders have the ability to break paradigms, to change the course of history.

Roberto Rodrigues, both for unveiling agronomic advances and for his work in promoting and organizing cooperatives, and Alysson Paolinelli, for his fundamental role in structuring Embrapa, are prominent leaders in the Brazilian agribusiness. The Brazilian citrus industry has had three undisputed leaders, who broke away from the traditional model: Edmond van Parys, José Cutrale Jr., and Carl Fischer. The first of them promoted innovations in production methods. The other two leaders innovated mainly in the operation of industrial plants, they leveraged the sector and turned Brazil into a benchmark in orange juice production. And by the way: it is impossible to talk about an industrial plant without mentioning the engineer Jacques Benchetrit, who designed them. Entrepreneurship is important, but it is not everything in tropical citriculture, which navigates phytosanitary challenges. How would we manage without leaders in research and technology transfer, such as Agesilau Antonio Bitancourt, Sylvio Moreira, Álvaro Santos Costa, Victoria Rossetti, Ody Rodrigues, Eurípedes Malavolta, Antônio Violante Neto, Santin Gravena, Walkmar Pinto Brasil, Joaquim Teófilo Sobrinho, Luiz Carlos Donadio, and José Roberto Postali Parra, among others?

And what would we have done without a renowned leader like Joseph Marie Bové, who

made correct predictions about greening even before the disease had been diagnosed in Brazil? Bové established the management tripod of greening (planting healthy seedlings, eliminating sick plants, and controlling the vector insect), which later was transformed into the ten commandments. He also called on the sector to promote joint control and was passionate about sharing knowledge. At Fundecitrus, he spearheaded the training of professionals, the expansion of laboratories, and he also created the biotechnology department, the most promising area for the development of long-lasting solutions against greening. But none of this would have been possible without the consent of the institution's leaders. Ademerval Garcia, Osmar Bergamaschi, and Lourival Carmo Monaco, among others, were important leaders for Fundecitrus, which, in turn, is crucial for the citrus industry. This is not about self-praising. It is a recognition widely acclaimed by the production chain and the international scientific community.

Deceased on November 29, 2024, at the age of 90, Monaco must be remembered for his comprehensive and diverse legacy: strengthening of the research and professional education departments, implementation of the Crop Estimate Survey (PES) and Tree Inventory, establishment and improvement of the Psyllid Alert system and of external actions to control greening, and the development of the Sustainable Citrus Farming program. As a technology enthusiast, he fostered the implementation of all digital tools that offer guidance to citrus producers.

He was a simple and upright man, ahead of his time in many areas, such as sustainability and technology, which he saw as complementary, with the latter supporting the former. He was passionate about science and agribusiness, always with a social vision in mind, seeking to understand citrus growers within their geographical, historical, and cultural conditions. He is one of those people who will be dearly missed. We are fortunate to have inherited his legacy: the advancement of the institution, whose sole purpose is to serve the sector. We rejoice that we were able to honor him in his lifetime for all his voluntary contribution to the Brazilian citriculture. 🍊



The Editorial department expresses, in a discursive, analytical, and informative manner, the strategic vision of Fundecitrus.

Citricultor

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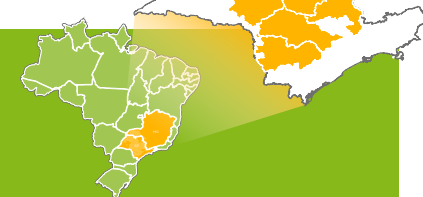
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BRAZILIAN CITRUS BELT

The São Paulo and West-Southwest Minas Gerais citrus belt, located in the Southeast region of Brazil and comprised of approximately 350 cities, is the main orange juice producing region in the planet: three out of five glasses of orange juice consumed in the world are produced here. In this region, citriculture creates 200 thousand direct and indirect jobs and collects 189 million dollars in taxes.



INTERVIEW

Márcio de Castro, director of Fapesp, talks about the role of the institution in seeking solutions for the development of science



SURVEY

Greening affects 44% of groves, but disease progression slows down



GREENING

In over 20 years of follow-up, research on the disease guided the development of management strategies, delaying adverse effects on production

HEALTH

Discover the benefits of orange juice for intestinal health



An invaluable legacy

THROUGHOUT HIS LIFE, DR. MONACO KNEW HOW TO SOW ON FERTILE GROUND AND BUILD COUNTLESS BRIDGES IN THE NAME OF CITRICULTURE

How to measure a man's values throughout his life? Responsibility, honesty, generosity, loyalty, empathy... How can this be measured empirically to arrive at a result, as if it were a mathematical equation? The answer is: this cannot be done. We know this, not only because we still do not have a formula that systematizes everything, but also simply because we lose track of it throughout life, in the various moments when these values come into play, balancing human relationships, shaping our experiences, and guiding our learning.

This was how Dr. Lourival Carmo Monaco's protagonism sowed this land, greatly contributing to making it fertile. Just

like a skilled farmer who only sows after carefully preparing the land, confident that the harvest will not fail to yield abundant fruit. We certainly did not lack good fruit. Wherever he went, Dr. Monaco left behind much of his intensive work and dedication. Since his days as an undergraduate student in Agricultural Engineering, sitting on wooden chairs at Esalq/USP, in Piracicaba (SP), through his international doctorate in the 1960s at the University of California (Davis/USA), a breeding ground for Nobel Prize winners, Dr. Monaco sought to carve out his own path.

In the 1970s, he gained prominence as director-general and researcher at the Agronomic Institute (IAC). Later, he

was appointed deputy secretary of the Ministry of Industry and Commerce, technical cooperation secretary of the Ministry of Mines and Energy in the 1980s, and in the 1990s, during the peak of Brazilian inflation — when everything was very expensive and money scarce, especially for investing in research — Dr. Monaco took upon himself the responsibility of instilling credibility into this line of work, performed by people who embrace knowledge, love to learn and love to teach, and took office as the President of the Financing Institution for Studies and Projects for nine years, an important organization under the sphere of the federal government.

From researching coffee, during his time at the IAC, Dr. Mo-

naco switched to researching oranges at Fundecitrus in 2008. At that moment, the sector gained not only a citrus farmer president, but a visionary, research manager, well ahead of his time. By the way, the future has always been by his side. For him, this "tomorrow" was not just rhetorical. It was mainly about the practice of management and the creation of innovative technologies to serve (well) those who sow the land to harvest, to live off it. Some say that an institution, a nation, has the leader it needs at particular moments in history. At Fundecitrus, Dr. Monaco arrived at the crucial moment to lead the institution in the battle against greening, discovered four years earlier. In times of un-



certainty, he planted the seed of trust, strengthening research and building the required national and international partnerships to jointly understand the effects of the disease and to implement effective management measures in order to reduce the adverse impacts of production losses.

Looking beyond the challenges, he envisaged what would soon be delivered by the hands of the future, he led the creation of the Crop Estimate Survey (PES) and the Citrus Belt Tree Inventory in 2014. He was daring to deploy a battalion of workers to explore long-standing groves in order to gain a better and deeper perspective of the sector. A citrus perspective on itself - after all, one needs to know themselves better in order to grow. The PES provided security, transparency, strict scientific standards, and credibility in data assessment, crop after crop. And in this exercise of looking itself in the mirror, citrus farming could better gauge its diseases and, more recently, it also recognized the breadth of its environmental responsibility - storing carbon in each planted orange tree and sheltering a diverse and exuberant fauna.

Dr. Monaco was one of those men who, upon looking at a grove, did not just see the land, trees, flowers, and oranges, he saw the future of the generations that were emerging and of others to come. He knew better than most that each orange tree growing in the field carries not

only the fruit of the present, but the possibilities of a prosperous tomorrow. A leadership that is built not only by wisdom, but by concrete actions.

Another fruit, sown by him, was the creation of the Sustainable Citriculture Program in 2021, which, aligned with the goals of the United Nations (UN), the universal principles of human and labor rights, meant an important step towards that envisaged future, by contributing to the sustainability of the citrus sector and impacting the economic, social, and environmental development of hundreds of municipalities and thousands of people whose lives are shaped by orange farming.

Dr. Monaco was also an enthusiast of technology as a facilitating tool to tackle the challenges of the farming fields. He spoke passionately about new ongoing research and constantly sought references to keep abreast of the novelties and of the benefits brought about by new technologies in citrus growing. A man ahead of his time, who was never tired of learning.

During his tenure at Fundecitrus, Dr. Monaco laid the groundwork to enable the fruits of the land to become the fruits of the mind as well. Instilled with this pioneering spirit, in 2024, Fundecitrus launched two virtual tools which are essential for managing greening: Avalia Psilídeo (Psyllid Assessment), which lists the most effective products for controlling the insect,

and Avalia Greening (Greening Assessment), which measures the quality of symptom-mitigating products.

In biotechnology research, Dr. Monaco planted his visions and, above all, as a citrus farmer, sowed hope for better days. Hope to revisit the atmosphere of a time when greening was just a word in English. The good news is that this seed of hope has already germinated with the construction of the Center for Applied Research in Innovation and Sustainability of Citriculture (CPA), an invaluable partnership between Fundecitrus, Fapesp, and Esalq/USP. A place where dreams shared by everyone will be forged into reality. The exchange of knowledge among researchers from different countries will be enhanced in the search for solutions to the disease.

Deeply engaged with everything that touched his heart throughout his life, Dr. Monaco was a sower of information, support, guidance, hope in difficult times, struggle, resilience, resistance, and dedication, above all, for the benefit of citrus farming. Few others were as wise to sow when most dared not, he planted with the certainty that others would come to reap. The sower thinks not of themselves, but of others, of those who will embrace the land as a nurturing mother. And when the future comes, it will be possible to see the fruits of a work that, upon being planned with love, is a true bridge to tomorrow. 🍊

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We lost a man, a leader, a master, and a friend. A man who dedicated himself with immense passion to science and agriculture, particularly to citriculture. He dedicated the last 16 years of his hard work journey to citrus farming and to the presidency of Fundecitrus, an institution that he led voluntarily and fearlessly, helping it become a world-renowned institution in research and development. Alongside God, Dr. Monaco will leave many fond memories and an invaluable legacy to Brazilian citriculture.

Juliano Ayres,
executive Director of Fundecitrus

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Dr. Monaco was very competent, with a strong personality. I followed his career as Secretary of Agriculture, president of FINEP, president of Fundecitrus, among other projects. He always worked with science at the forefront. His passing was a great loss for Brazilian science and particularly for citrus growing.

José Roberto Postali Parra,
researcher at Esalq/USP -
University of São Paulo

★

Having had the opportunity to share experiences and work with Lourival Monaco was a privilege in my life. After having had the opportunity to work and learn from him, in the last eight years at the Fundecitrus Board, I have truly changed the way I deal with certain day-to-day situations and difficulties. Dr. Monaco was calm, discerning... He worked without the slightest need for applause or to display his brilliant work.

Sarita Junqueira Rodas,
citrus grower

Tributes

Competent professional, a leader, with excellent education. He used these characteristics to lead several research institutions, in favor of coffee and citrus farming, which he mastered as a producer and technician, which proved highly relevant at Fundecitrus. For many years, Dr. Monaco has helped to combat diseases such as CVC, citrus canker, sudden death, and greening, among the most important ones, leading teams of technicians and guiding the work that results in the viability of the Brazilian citrus industry.

Luiz Carlos Donadio,
full professor at FCAV-Unesp

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The memory of Dr. Monaco will live on, although he will not be physically present among us, but we are confident that in another plane he will be supporting us and sending positive energies to everyone here on Earth. The Brazilian citriculture is grateful to him for all his efforts and dedication over the years.

Eurides Fachini,
citrus grower

★

Dr. Monaco was a reputable, proactive, visionary, and friendly professional. He was demanding when it came to producing results, but ready to help those who needed him. As president of Fundecitrus, he provided significant and fruitful voluntary work to the citrus industry. He was the right person at the right time to organize Fundecitrus. Today, it is a recognized research institution inside and outside Brazil.

Joaquim Teófilo Sobrinho,
former director of the Citrus
Center at the IAC

Before becoming the forward-thinking president of Fundecitrus, Dr. Monaco was, among other things, a renowned scientist. Upon leading the IAC, he summoned the young researchers and offered them the opportunity to study abroad, as he had experienced himself. He organized scholarship programs and sent over a dozen researchers overseas, ensuring that the IAC had a generation of well-trained scientists. I am a witness to this, as I was one of the recipients of a scholarship to the United States.

Heitor Cantarella,
director of the Soil and Fertilizer
Research Center at IAC

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Most of our interaction took place at the beginning of our careers, in the 1950s, while still students. We met again in the 1980s, when Dr. Monaco was in Brasília and later in Rio de Janeiro. Since 2008, when he took over the presidency of Fundecitrus, we had several cooperative research projects involving citrus pathogens. His excellent academic background, coupled with his managerial mastery, turned him into an acclaimed Science Administrator, and that is the image that I will carry with me.

Elliot Watanabe Kitajima,
researcher at Esalq/USP -
University of São Paulo

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"Fapesp is a state agency and a global benchmark"

STRATEGIC POSITIONING INDICATES THE CONNECTION BETWEEN SOCIETAL DEMANDS PRESENTED BY THE GOVERNMENT AND THE INSTITUTION'S ROLE IN SEEKING SOLUTIONS, AS IN THE CASE OF GREENING, THROUGH FINANCING FOR SCIENCE



Márcio de Castro Silva e Filho

State issues require a State Agency for Scientific and Technological Research funding. Greening has become a priority on the government agenda of the state of São Paulo since it jeopardizes the viability of citrus farming, one of the agribusiness activities that generates the highest number of jobs per hectare. And the risk is as undeniable as it is imminent.

The creation of the Center for Applied Research in Innovation and Sustainability of Citriculture (CPA), a partnership between Fundecitrus, São Paulo Research Foundation (Fapesp), and the School of Agriculture of the University of São Paulo (Esalq/USP), connecting 75 researchers from 25 institutions in Brazil and abroad with the aim of establishing an intelligence network with high capillarity to address plant breeding and plant resistance to the psyllid and bacteria, disease spread and damage control,

among other fronts, in addition to training 100 scholarship holders per year, thereby recruiting additional great minds for the battle, represents the largest response to greening in the history of Brazilian citriculture.

The scientific director of Fapesp, Márcio de Castro Silva e Filho, recalls the historical relationship between citrus farming and the institution to explain his enthusiasm for the center. "The bond was first established right in the first week of Fapesp's operation. There is an interesting passage. On the same day he received the car he was entitled to use for work, Fapesp's scientific director, Warwick Estevam Kerr, had a meeting with the researcher from the Biological Institute, Victoria Rossetti, who was deeply engaged with citrus farming and complained about the need for a vehicle to travel through the countryside. What did he do then? He took the car key and gave it to her, "Victoria, keep this car for yourself." The field of agricultural sciences has always been relevant for Fapesp," he explains.

By the late 1990s and early 2000s, Fundecitrus and Fapesp, upon connecting institutions and researchers, solved the problem of Citrus Variegated Chlorosis (CVC), which had reached a prevalence level of 43.8% in orange trees in São Paulo and Minas Gerais states in 2004 – the current incidence is 0.45% (2024), a reduction of nearly 80 times. This intelligence network has yielded a package of applications that innovated the phytosanitary management of citriculture, including

measures incorporated in the fight against citrus greening, such as planting healthy seedlings from screened nurseries, eliminating diseased plants, and monitoring and controlling the insect that transmits the bacteria with much higher quality due to the knowledge acquired. And to top it off, the Genome Project enabled the first genetic sequencing of a plant pathogen in the world, *Xylella fastidiosa*, the bacterium that causes CVC, an achievement that made the cover of the prestigious Nature magazine on July 13, 2000. We know the story. May the future allow us to repeat it.

WHAT ARE THE MAIN CHALLENGES FACING FAPESP TODAY AND WHAT ARE THE MAIN CHALLENGES FACING THE INSTITUTION'S SCIENTIFIC DIRECTOR?

One cannot look ahead without knowing or remembering some of Fapesp's history and its focus over these six decades of operation [established in 1962, as provided for in the Constitution of the State of São Paulo of 1947]. Fapesp started financing research according to researchers' interests, that is, it was a bottom-up approach. From a certain angle, this is what happens in most funding agencies around the world. Later, some initiatives started to emerge after the determination of strategic themes. Decisions are made from top to bottom in this case, based on suggestions, conversations with different segments of society and discussions with the community or specific

groups, leading Fapesp to be more interested in cross-cutting themes, such as climate change, biodiversity, bioenergy, and public policies. Moreover, the research work, which could be considered strictly academic, gained an important component of technological development connected to innovation, and Fapesp also started financing research projects in partnership with society organizations, companies, and governments. Today, Fapesp has a highly diversified portfolio, with partnerships with international funding agencies. This background context about the financing models was an important note to make.

HOW ABOUT THE CURRENT CHALLENGES?

We are truly living in a world of very rapid transformations, especially considering the current developments in artificial intelligence, which was not an item in our agenda 10 or 15 years ago, but today it is an undeniably important vector that permeates all areas of knowledge. One of the challenges is precisely keeping up with the evolution of science in the world. Other challenges include constantly raising the bar of excellence in the areas where Fapesp operates, working in partnerships, because major breakthroughs require intersections, and achieving a broader application of research in society by meeting the needs of government issues.

YOU ARE CERTAINLY TALKING ABOUT THE RELATIONSHIP BETWEEN SCIENCE

CE AND PUBLIC ADMINISTRATION, SO THAT, AT THE END OF THE DAY, RESEARCH GENERATES SOLUTIONS FOR PEOPLE. HOW IS THE DIALOGUE BETWEEN FAPESP AND THE GOVERNMENT OF THE STATE OF SÃO PAULO?

Fapesp has created a funding line called Science Centers for Development, which basically meets the demands of state departments. Problems are brought in, and then they are addressed with the scientific and technological approach of the academic environment. Just now [June 2024], we have announced 21 new Science Centers for Development [there are already 25 in operation], in which Fapesp is investing BRL 128 million, precisely to address issues brought by state governments. Making society understand that economic and social advancements are strongly related to the progress of research also constitutes a major challenge.

WHAT ARE THE CHALLENGES OF THE SCIENTIFIC BOARD?

We conducted a very detailed survey on the workflows and a very comprehensive intervention to reduce bureaucracy, simplify processes, shorten deadlines and evaluation time, and give researchers more autonomy. We need to emulate other agencies around the world, funding should not be provided if researchers lack freedom to work. Clearly, this is an ongoing movement, several actions are already in place, and many more will come.

WHAT IS THE RELATIONSHIP BET-

WEEN FAPESP'S CONTRIBUTIONS AND THE PROWESS OF THE STATE OF SÃO PAULO?

Fapesp invests in the training of human resources – undergraduate, master's, doctorate, and post-doctorate research. It channels its resources to science, with a direct impact on innovation and technological development. The Foundation has already financed over 2,000 startups. The investments that Fapesp made in innovation and technology have certainly yielded much more return than the investments made by the government in the institution itself.

IS THERE ANY NUMBER TO MEASURE THE EFFICIENCY OF INVESTMENTS?

A study conducted a few years ago on the impact of research funding [and of higher education and technology transfer] in agriculture showed that for every BRL 1 invested, the return was BRL 12 [study coordinated by the Esalq/USP professor Paulo Fernando Cidade de Araújo, published in 2016, with data from 1970 to 2014].

WERE YOU LISTING CONTRIBUTIONS?

There are countless cases. There are research projects in the bioenergy field, and the Brazilian Forest Code, for example, which used research developed in Bio-ta-Fapesp [Research Program on Characterization, Conservation, Recovery, and Sustainable Use of Biodiversity in the State of São Paulo]. São Paulo is the state that

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THE CREATION OF THE CPA IS ONE OF THE MOST INTELLIGENT AND CREATIVE WAYS TO ADDRESS A REAL PROBLEM OF THIS MAGNITUDE. GREENING POSES THE GREATEST CHALLENGE FOR CITRUS PRODUCTION WORLDWIDE

most produces knowledge about the Amazon. Fapesp can rely on its capillarity. The results demonstrate extraordinary achievements, and the institution is concerned about promoting scientific dissemination, about showcasing to society the result of investments, and the direct transformation in people's lives. So, in conclusion, Fapesp is a distinguishing factor in the state of São Paulo, it was the first research support foundation in Brazil, and it is the foundation that operates most consistently, with no highs and lows in its funding history. Long-term financing is hardly found, it is not available in Brazil, not even worldwide, and with the stability of resource allocation, researchers can work in a predictable fashion. Today, Fapesp has funding programs spanning 10 to 11 years, projects that transcend the current administration. Fapesp is indeed a State agency.

YOU ARE AN AGRICULTURAL ENGINEER, SPECIALIZED IN THE INTERACTION BETWEEN PLANTS-INSECTS-PATHOGENS, WHICH IS EXACTLY THE MODEL OF GREENING. YOU HAVE A VAST ACADEMIC AND SCIENTIFIC

BACKGROUND IN GENETICS AND MOLECULAR BIOLOGY, AND YOU WERE A MEMBER OF THE NATIONAL BIO-SAFETY TECHNICAL COMMISSION (CTNBIO). HOW CAN BIOTECHNOLOGY HELP CITRICULTURE?

First and foremost, it is very important to see biotechnology as a product of scientific advancement in various fields, including the transfer of genes from different kingdoms. Biotechnology is disruptive. It is an extraordinary tool of knowledge, not only in agriculture but also in the health industry. And the genomic editing technique, which enables a very particular and precise replacement with no transfer of sequences from other organisms, has recently made biotechnology an even more prominent discipline. So much so that Brazil and many other countries recognize this technology as a non-transgenic tool, precisely because it does not bring segments of DNA from other species besides the one being manipulated [CRISPR-Cas9 technology]. Biotechnology is a very powerful tool, but I do not believe it works in isolation. It needs to be integrated into a larger process that involves plant improvement, all the ecological aspects of interconnected systems, and management. It's not a silver bullet.

WHAT ARE YOUR CONSIDERATIONS ABOUT THE CENTER FOR APPLIED RESEARCH IN INNOVATION AND SUSTAINABILITY OF CITRICULTURE (CPA)?

I am very happy to have the opportunity to discuss this topic

because the partnership and the creation of the center is one of the most intelligent and creative ways to address a real problem of this magnitude. Greening poses the greatest challenge for citrus production worldwide. We are resuming a historical partnership. Fapesp and Fundecitrus worked together in the fight against CVC, a disease which was successfully tackled. This partnership has thrived once, and I am absolutely convinced it will yield positive results again. And based on the conceptual design of the CPA, it will become one of the best partnership cases in the world because of the common understanding of the urgency of the matter, joint funding, sharing of risks, and the institutions' highly qualified teams.

IS IT POSSIBLE TO SAY THAT THIS IS A PARTNERSHIP THAT ENGAGES MORE THAN STATE INSTITUTIONS, THAT IT ALSO INVOLVES THE GOVERNMENT ITSELF?

Yes. In a conversation with the secretary [of Agriculture and Supply of the state of São Paulo] Guilherme Piai, a very pro-

ductive exchange resulted in the definition of the priorities of the state government regarding the agricultural and livestock sector, which includes greening, and consequently, the establishment of the CPA. There is also a similar program for the sugar and ethanol sector, since the sugar cane productivity has been stagnant for several years. Sugarcane and orange are the most important agricultural sectors for the state of São Paulo. There is a very strong interest in fertilizers and bio inputs, which is also driven by the society demand to reduce the use of chemical molecules. There is already a very successful biological control program, spearheaded by Esalq, under the management of Professor Parra. Once again, the CPA model, with researchers from São Paulo, Brazil, and foreign references, promotes exchange and synergy, which may help to respond to the challenge in a very qualified way, operating in an integrated and coordinated manner. This demonstrates the importance of academia and research alongside the productive sector and society. 🍊



The CPA will be headquartered at Esalq/USP, in Piracicaba (SP state)

The largest research network

for the world's largest citrus belt

CPA IS THE RESULT OF A SOLID PUBLIC-PRIVATE PARTNERSHIP BETWEEN FUNDECITRUS, FAPESP, AND ESALQ/USP FOR THE DEVELOPMENT OF A WORLDWIDE RESEARCH NETWORK, KNOWLEDGE DISSEMINATION, AND TECHNOLOGY TRANSFER TO FIGHT AGAINST GREENING

The world's largest citrus belt should have a research center compatible with its size." The statement comes from the French Dr. Joseph Marie Bové (1929-2016), one of the most renowned researchers in phytopathology that has ever worked in the global citrus industry. Bové played a decisive role in the discoveries and advances aimed at controlling the main diseases of Brazilian citrus farming, such as CVC (huanglongbing), citrus sudden death, and especially the worst of them, greening. Furthermore, he was a visionary and worked intensively to promote research in Brazilian citrus farming, the world's largest exporter of orange juice.

His inspiration, sown over se-

veral years through his research, has been yielding good results. The last of them was announced in December at a ceremony at the Bandeirantes Palace, headquarters of the São Paulo state government. The Fundecitrus, the São Paulo Research Foundation (Fapesp), and the Luiz de Quei-

THE CENTER WILL FURTHER STRENGTHEN CITRUS FARMING IN THE STATE OF SÃO PAULO TO FIGHT AGAINST GREENING, EXPANDING OPPORTUNITIES THROUGH THE WEAVING OF PARTNERSHIPS THAT FOSTER RESEARCH DEVELOPMENT

roz School of Agriculture (Esalq/USP) will double their efforts in the battle against citrus greening with the creation of the Center for Applied Research in Innovation and Sustainability of Citriculture (CPA), the largest industry-oriented research center in the world.

The center will be granted investments amounting to BRL 200 million in the next five years, renewable for another five. Out of this total sum, BRL 90 million will come from Fundecitrus and Fapesp, with the remaining resources corresponding to non-financial contributions, in the form of investments in infrastructure, technicians' compensation, among others. The CPA will have the mission of developing rese-

arch, disseminating knowledge, and transferring technology to the sector, which accounts for 8.2% of São Paulo's exports and 45,000 jobs in the state.

Its main line of work will be to promote the formation of new research groups and to consolidate other previously established teams, aiming at controlling greening, particularly in fields of knowledge that are not currently covered. According to Juliano Ayres, executive director of Fundecitrus, the joint construction of the CPA is an achievement that stemmed from a broad coalition committed to the sector. "We are currently in the process of making a dream come true! The CPA represents the joint construction of a project that has a very clear objective, which is to promote the phytosanitary and economic sustainability of citrus farming that is paramount for the economy of the state of São Paulo. By implementing the CPA, we renew, once again, the public and private commitment to the sector in the face of the serious challenge of mitigating the incidence of greening and, in

the future, of finding a sustainable path for disease prevention and/or cure," he affirmed.

For the emeritus professor of FGV and former Minister of Agriculture, Livestock, and Supply, Roberto Rodrigues, a passionate supporter of the sector, the Applied Research Center exemplifies how public-private partnerships can thrive, fostering scientific advancements and, consequently, economic growth. "My relationship with citrus farming comes from birth. A country that does not value science has no future, as its development is indispensable. There is no science without scientists. There are no scientists without training and institutions that drive their growth. Science is the foundation of a nation's development, and scientists are the levers of this entire mechanism," says Rodrigues.

IMPACTS OF THE DISEASE

Currently, the total number of properties where citrus is grown has nearly been halved compared to the pre-greening period. The orange production area de-

creased by 36.5% and the fruit is being produced at approximately 20% higher cost. Annual surveys have shown a dramatic increase in trees affected by greening, from 0.6% in 2008 to 44.4% in 2024, on average. In some traditional citrus farming regions, the disease incidence exceeds 60%. Only in 2024, the incidence of greening affected 90.7 million trees that are irreversibly condemned, just like the 64 million additional trees that have been eliminated since 2004 in an attempt to control the disease.

"The disease draws a great deal of attention due to its ability to negatively impact the productivity of groves, jeopardizing the sustainability of an entire productive chain. The CPA was designed to discover pathways and provide answers for more effective disease management in the short term. Our work will focus on meeting this highly important demand and minimizing the impact on crops," stresses Lilian Amorim, a researcher at Esalq/USP and director of CPA.



The establishment of the CPA was attended by the Governor of the State of São Paulo, Tarcísio de Freitas; Marco Antonio Zago, President of Fapesp; Guilherme Piai, Secretary of Agriculture and Supply, and other government secretaries, at the Bandeirantes Palace

CPA IN NUMBERS

36

departments
of 21 institu-
tions

7

countries
involved

75

research-
ers

129

scholarship
granteesR\$
200Budget of
BRL 200
million

In the last five orange crops, citrus greening caused premature fruit drop equivalent to 97.2 million boxes, leading to an estimated revenue loss of USD 972 million. This scenario has been further worsened by the growing population of the vector insect in recent years, which increased more than tenfold from 2019 to 2024. This proliferation, among other factors, originates from the selection of individual insects resistant to insecticides, anticipating the progress of the disease in forthcoming years.

PERFORMANCE

The main academic research lines of the CPA encompass the understanding of pathogen-plant-vector interactions, with emphasis on the host (citrus) histopathology, physiology, and metabolism, as well as on the genetics of the plant-pathogen-host interaction, and consequences of climate change.

Applied research involves greening management, with emphasis on host genetic resistance and on chemical, biological, physical, and crop control measures of the bacterium and its vector. Another applied research line, focused on damage mitigation and increased production, will emphasize production systems, plant nutrition, damage reduction, loss assessment, disease occurrence risk, and economic analysis of management measures and their impacts. However, research on other aspects of the culture may be developed in the future.

According to Guilherme Piai, Secretary of Agriculture and Supply of the state of São Paulo, the citrus industry in São Paulo is a showcase for the world, with significant impacts on socioeconomic aspects. "We are talking about a sector that holds the position of the largest exporter of its segment on the planet." The state of São Paulo endeavors to make citrus

growing increasingly stronger to face this challenging disease, and this is only possible through the establishment of partnerships that foster the development of research. The CPA will leverage the best resources in our state in terms of investment opportunities and research professionals. We are very optimistic about harvesting results and disseminating knowledge," he reveals.

In addition to research projects, the CPA will gear considerable efforts in education, knowledge dissemination, and technology transfer. In education, the center will invest in human resources training activities, which have already been developed by partner institutions, such as *stricto* and *lato sensu* graduate programs, as well as distance learning, online courses, aiming to reach a broader and more diverse audience. Technology transfer will be performed by researchers from

CPA as well as technicians from CATI and the Agriculture Department of the state of São Paulo.

The CPA will be headquartered at Esalq/USP, in Piracicaba city (SP state). In addition to Fundecitrus, the center will have researchers from other units of the University of São Paulo (USP) (Cena, FZEA, FCFRP), UFSCar, Unicamp, Biological Institute, Unesp, IAC, and Embrapa. Researchers from ten foreign institutions will also join the CPA in creating knowledge for the benefit of citrus farming (See *more below*). The CPA will be a joint and unprecedented effort by the world's leading researchers, whose core focus is the disease that most affects groves. We are certain that we will further strengthen citrus farming in the state of São Paulo with the results produced by our research projects. "We are reinventing citriculture through this noteworthy partnership," concludes Ayres. 🍊

HISTORICAL PARTNERSHIP

Fundecitrus, Fapesp, and Esalq/USP have had a partnership for nearly two decades in research development, working together to combat the main citrus diseases, such as CVC (*huanglongbing*), citrus sudden death, and especially greening. "The partnership between Fapesp and Fundecitrus is historical. Together we have achieved important research results over nearly 20 years aimed at establishing effective strategies for mitigating and understanding greening. Now, we are taking a very important step that will transform citrus farming in the state of São Paulo," explains Márcio de Castro Silva e Filho, scientific director of Fapesp. In 2000, the two institutions partnered on the Genome Project, which sequenced for the first time the genome of a bacterium of economic interest, *Xylella fastidiosa* – the causative agent of citrus variegated chlorosis, advancing biotechnology research in the country.

CPA PARTNERSHIPS AROUND THE WORLD



In the name of science, for the benefit of citriculture

PARTNERSHIP BETWEEN FAPESP AND FUNDECITRUS BOLSTERS STUDIES ON MANAGEMENT MEASURES TO REDUCE GREENING INFECTION OVER THE YEARS, TRANSFERRING KNOWLEDGE TO THE FIELD

The French researcher Louis Pasteur (1822-1895) coined one of the most important quotes about the importance of science. In his opinion, "the scientist does not benefit from his discoveries, but humanity does." The Brazilian citrus industry has a historical relationship with science, especially after the emergence and expansion of the first juice industries. Built by the hands of renowned researchers from Brazil and other

countries, citriculture science has managed to understand and treat the main diseases that affect groves, as well as to outline very important paths for managing greening, the sector's greatest phytosanitary challenge in history. This knowledge is generated by researchers and transferred to the citrus industry in Brazil and abroad.

Since the emergence of greening in São Paulo in 2004, with the support of important partners, research related to

the disease has gained robust support, enhancing the understanding of the bacteria's mode of action and its effects on the psyllid, and also determining the most effective strategies for mitigating a problem that still has no cure. The main scientific projects on the disease have had the unconditional support of the São Paulo Research Support Foundation (Fapesp) since 2005.

Since then, there have been six thematic projects with the

important participation of researchers from Fundecitrus that have covered various fronts of studies related to greening, an investment of approximately BRL 9 million. "Without a shadow of a doubt, we can say that much of what we know today about greening is in virtue of the support provided by Fapesp for the financing of studies and, consequently, the transfer of this knowledge to citrus growers who are in charge of the groves," says Juliano Ayres, executive director of Fundecitrus.

INFECTION REDUCTION

The most recent thematic project, which kicked off in 2019 and was concluded this year by Fapesp and Fundecitrus, evaluated the technical and economic feasibility of measures applied inside and outside groves with the aim of reducing greening infections. Important research fronts were created, such as measures to control the primary source of inoculum, actions to prevent or reduce psyllid dispersion, inoculation of the bacteria causing the disease, and cost-benefit analyses of management measures.

Over the years, the work has resulted, so far, in seven important articles in scientific journals (with another ten articles in an advanced stage of preparation for submission), 23 abstracts in scientific conference proceedings, three master's theses, and seven technical papers in high-circulation citrus industry magazines. 🍊

MAIN RESULTS

The last thematic project by Fapesp coordinated by Fundecitrus on greening management resulted in:

Practice of removing diseased plants in the vicinity of groves

Protocol for the release of the parasitoid *Tamarixia radiata*

Farming in areas less favorable to the psyllid and the bacteria

Farming of the border plots along the property perimeter

Plant densification in border plots

Pruning at more appropriate times

Higher spraying frequency during budding

Use of processed kaolin

Validation of the concept of bait planting

THEMATIC PROJECTS RELATED TO GREENING, WITH THE PARTICIPATION OF FUNDECITRUS, TOTALED APPROXIMATELY BRL 9 MILLION

KNOWLEDGE THAT IS PASSED FORWARD

According to the Fundecitrus researcher and project coordinator, Renato Bassanezi, it is our duty to convey the information of all the work developed and knowledge generated to citrus growers in the field, thereby benefiting the entire society. "The positive impacts of measures for managing greening that were discovered through scientific research only yield results when they are effectively transferred to the field, enabling citrus growers to make practical use of this knowledge," he explains. Some results of these studies, which are already widely used by citrus growers, include the removal of sick plants around commercial properties, release of the biological control agent *Tamarixia radiata*, migration of new plantings to less favorable areas for the psyllid and the disease in the state of São Paulo, planting edge rows in the perimeter of the property boundaries,

densification of planting in edge rows, pruning at times of lower production loss and attention to psyllid control after pruning, increased spraying frequency during shoot development, and application of kaolin as a repellent. With the advancement of studies, it was possible to demonstrate that some practices that were being used by citrus growers, such as spraying the plants around the plot and spraying on alternate rows, had little effect in controlling the disease. This realization helped producers to focus their actions and resources on more effective measures. "A significant share of the current greening management measures used in our citrus belt groves result from the combined efforts of dozens of researchers and a dedicated program by Fundecitrus focused on education, knowledge dissemination, and technology transfer," he concludes.

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Fundecitrus
SCIENCE AND SUSTAINABILITY
IN CITRICULTURE

Greening reaches 44%, but disease progression slows down

THE INCREASE IS RELATED TO THE HIGHEST HISTORICAL RECORD OF PSYLLID CAPTURES IN 2023, HOWEVER, DISEASE PROGRESSION IS LOWER THAN THE PREVIOUS YEAR; EFFECTIVE MANAGEMENT MEASURES CANNOT BE INTERRUPTED BY CITRUS GROWERS

The annual survey of greening (huanglongbing/HLB) incidence, produced by Fundecitrus, indicates that the disease rose, in average, from 38.06% in 2023 to 44.35% in 2024 in the São Paulo and West-Southwest Minas Gerais citrus belt. This is the seventh consecutive year of growth of the worst disease in the global

citrus industry. The incidence corresponds to approximately 90.4 million affected orange trees. In total, there are 203.7 million orange trees in the entire citrus belt. The spreading of the disease is a reflection of the highest historical population of psyllids that was measured in 2023, when the average trap capture increased by 54% compared to 2022. On the other hand, even with the rise represented by a difference of 6.3% in the incidence rate this year, the

number was significantly lower than the 13.7% increase from 2022 to 2023.

According to the survey, this is a good indicator of a slower evolution pace of the disease, nevertheless the scenario still raises concerns and continues to demand effective measures from citrus growers to mitigate the disease in their groves, mainly through proper psyllid control and elimination of diseased plants. "The advancement of greening has

been a reality in our citrus groves for seven years. This has not changed! Citrus farmers and industry professionals, who manage the groves daily, need to carry on with the work that has been done to mitigate the disease and effectively control the psyllid. In this battle against the worst citrus disease, there is no room for letting our guard down. All guidelines provided by Fundecitrus must continue to be implemented throughout the citrus belt," says Fundecitrus executive director, Juliano Ayres.

RELATED FACTORS

One of the possible assumptions related to the

slowing down of the pace of the disease, from one year to the next, is that during most of the second half of 2023 and early 2024, temperatures were higher than normal in the entire citrus belt. In the North and Northwest regions, where the incidence of the disease was low in 2023, a greater number of days at maximum temperatures exceeding 35°C was recorded.

According to the researcher and consultant of Fundecitrus, Silvio Lopes, this may have prevented new infections. "Although these heat waves were not enough to reduce the psyllid population, they may have affected the

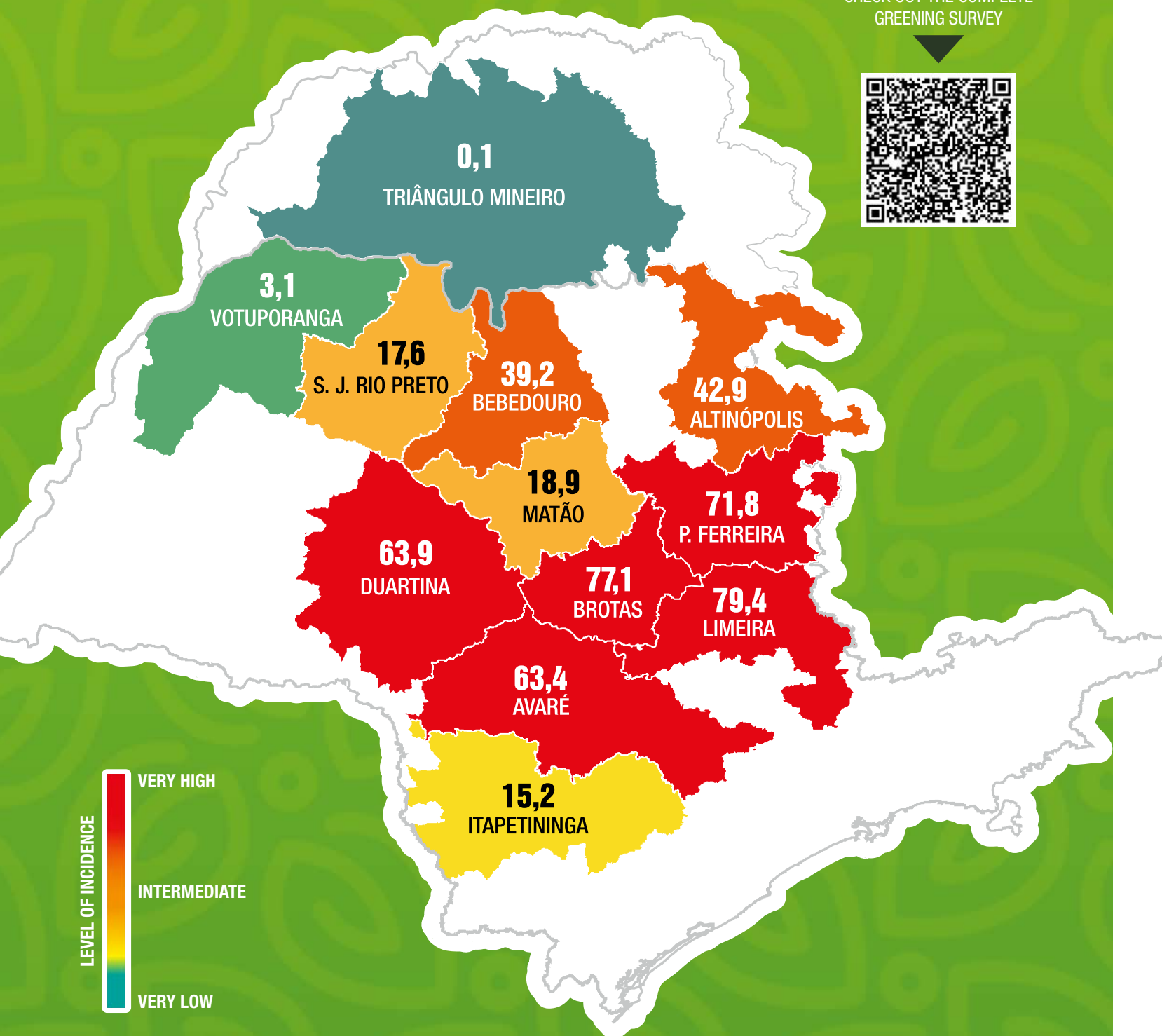
multiplication of bacteria in the buds, negatively interfering with the contamination and transmission of bacteria by the psyllid," says Lopes.

Furthermore, the change in producers' stance in the face of the advancement of greening, along with the implementation of effective management actions, also led to the deceleration of the disease. The actions encompass the eradication of severely affected groves, planting in areas with lower incidence of greening, carrying out external actions to reduce inoculum, and holding meetings with groups of producers to coordinate a regionalized management.

EVOLUTION OF CITRUS GREENING AND PSYLLID POPULATION



PERCENTAGE OF ORANGE TREES AFFECTED BY GREENING BY REGION

CHECK OUT THE COMPLETE
GREENING SURVEY

These measures, always advocated by Fundecitrus, were implemented in the field and the results were quite positive. "This work cannot stop," concludes Fundecitrus researcher, Renato Bassanezi.

REGIONS

Out of the 12 regions of the citrus belt, five have an incidence rate above 60%, two are close to 40%, three range between 15 and 25%, and only two regions have an incidence rate below 5%. (See more on the map). The regions with the highest incidence rates in 2024 continue to be Limeira (79.38%), Brotas (77.06%), Porto Ferreira (71.77%), Duarteina (63.93%), and Avaré (63.41%).

The Altinópolis region remained in the group with a high incidence of greening (42.93%), followed closely by the Bebedouro region (39.17%), which had the highest growth in percentage points. The regions of Matão (18.91%), São José do Rio Preto (17.57%), and Itapetininga (15.19%) have registered an intermediate range. However, it is important to highlight that Itapetininga showed an increased incidence rate compared to the previous year. In Rio Preto, a decrease was registered, while Matão, despite a slight increase, kept its incidence level stable. The regions of Votuporanga (3.14%) and Triângulo Mineiro (0.11%) continue to

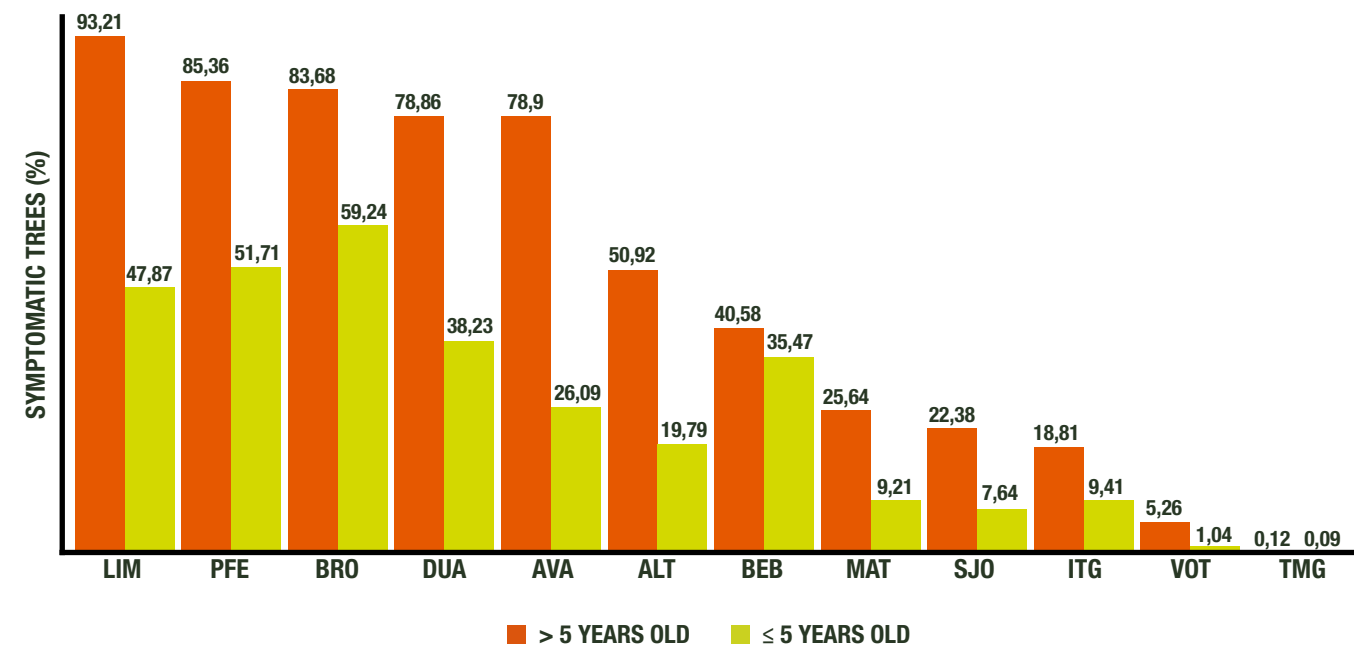
THE BATTLE
MUST BE
INTENSIFIED

The guidance from Fundecitrus is that greening management should be adjusted according to the disease incidence in the region where the property is located. In regions and properties with higher incidence of the disease, it is recommended to intensify the control measures for greening within commercial groves. "It is essential to maintain a strict approach in psyllid control, with high-quality applications, at a maximum 10-day interval between applications, and rotate effective insecticides so that diseased plants do not serve as a source of inoculum and accelerate the spread and severity of the disease within the grove and into neighboring groves, resulting in shortened productive longevity of farmed areas," says Bassanezi. In regions and properties with low incidence of greening, it is indispensable to keep eliminating diseased plants

within the grove, in addition to conducting psyllid control measures and reducing external inoculum sources. "Before replanting, external actions to eradicate diseased plants in neighboring groves, rural and urban yards, and pasture areas within a radius of up to five kilometers around the property, is highly recommended, and this can be done in partnership with Fundecitrus. The more we shield the property, the lower the risks," the expert adds.

THE AVERAGE SEVERITY HAS BEEN INCREASING YEAR ON YEAR, NOT ONLY DUE TO THE HIGHER PREVALENCE OF SICK PLANTS IN THE FIELDS, BUT ALSO BECAUSE OF THE EVOLUTION OF SYMPTOMS IN PLANTS THAT HAVE NOT BEEN ELIMINATED BY CITRUS GROWERS

ORANGE TREES WITH GREENING IN GROVES UP TO 5 YEARS OLD AND OVER 5 YEARS OLD



have the lowest incidence rates. However, in Votuporanga, a significant increase in the disease was observed compared to the previous year (77.4%), while a reduction in incidence was observed in the Triângulo Mineiro (68.6%).

INCIDENCE BY AGE

According to the survey, the highest incidence rate continues to be observed in groves over 10 years of age (54.25%), followed by groves ranging from 6 to 10 years of age (52.46%), 3 to 5 years of age (47.24%), and 0 to 2 years of age (5.93%). The incidence of greening had a slight decrease of 9% in the 0 to 2 years group but increased

in the other age ranges of the groves. In relation to 2023, there was an 8.2% increase in the age group above 10 years, 37.4% in the 6 to 10 years old group, and 35.6% in the 3 to 5 years old group. "As warned in previous years, the higher the incidence of greening in groves over 5 years of age in the region, the higher the incidence of the disease in groves younger than 5 years of age, which demonstrates that maintaining diseased plants in adult groves without appropriate psyllid control is extremely harmful to the establishment of new groves, even if these young groves receive strict psyllid control," says Bassanezi. (See more in the chart above).

SEVERITY

Of the symptomatic trees, 41.3% have less than 25% of their canopy affected by symptoms (level 1); 20.8% have severity level between 26% and 50% (level 2); 15.9% between 51% and 75% (level 3); and 22% show symptoms in over 75% of their canopy (level 4). In the researcher's opinion, the average severity of the citrus belt has been increasing every year, not only because of the higher prevalence of diseased plants in the fields, but also due to the progression of symptoms in plants that were not eliminated by citrus growers. (See more in the chart on page 21). 🍊

GREENING
IS SERIOUS STUFF

20 years united against greening:

paths, lessons learned and hope

THE ARRIVAL OF THE DISEASE IN BRAZIL, IN 2004, PROMPTED RESEARCH PROJECTS IN THE SECTOR TO UNDERSTAND ITS EFFECTS AND DEVELOP MANAGEMENT STRATEGIES; AN ESSENTIAL COMBINATION TO SLOW DOWN THE DISEASE CONSEQUENCES ON PRODUCTION LEVELS

In 2004, greening was detected for the first time in Brazil, in the interior region of the state of São Paulo, in the heart of the citrus belt, and, one year later, in Florida (USA). Since then, the citrus industry has never been the same. In the early 2000s, the citrus belt of São Paulo state, West-Southwest Minas Gerais state, and Florida state vied for the title of the world's leading producer of orange and orange juice. After 20 years, this scenario has undergone changes with the intensification of symptoms and damage on the groves as a result of the disease. In Florida, fruit production and grove productivity have plummeted, with disease prevalence affecting as much as 90% of orange trees.

In the citrus belt, the impacts of the disease have been mitigated over time thanks to the management strategy recommended by Fundecitrus. The strategy is based on fundamental and preventive action fronts, such as planting healthy seedlings, eliminating diseased plants, and controlling the psyllid, both inside and outside commercial groves, and its success also relies on the trust placed in producers' compliance to actions that will safeguard the sector's economic viability. Investments in research and mitigation of greening have reached nearly BRL 500 million over these 20 years. "The impact of greening was very significant. Considering the severity of the disease, we can say that the lear-

ning and volume of knowledge generated by research, most of it with the participation of Fundecitrus, established solid foundations to attenuate the disease destructive power in the groves, reaching the levels we experience today. We have come a long way so far, and we still have a lot to accomplish with the support of citrus growers," says Juliano Ayres, executive director of Fundecitrus.

IMPACTS

Historical data on citrus belt production in Florida and Brazil demonstrate how disease prevention measures adopted in Brazil had a superior effect compared to the attempt based on coexistence and damage mitigation adopted in Florida. By 2004, for example, Brazil's citrus park had an area with productive orange trees (plants over three years old) that was 2.7 times larger than Florida's, and its production was 1.5 times higher than that of the American state. However, the average productivity, in terms of boxes produced per hectare in the five crop seasons before the emergence of greening, was 1.7 times higher in Florida, which produced an average of 895 boxes/hectare, while the Brazilian citrus belt produced an average of 534 boxes per hectare.

After 20 years, despite the area with productive orange trees in SP and MG states having shrunk 45% and orange production continuing to be sea-

sonal - with alternating high and low yields due to climate adversities - productivity increased by 41%, which represents a slight production loss. *(See more in the chart on page 28).* On the other hand, in Florida, the area with productive orange trees decreased by 57%, and both production and productivity went down significantly by 88% and 72%, respectively. The productivity of the citrus belt surpassed that of Florida in 2014. Currently, Brazil remains the world's leading orange producer, while the United States ranks sixth.

LEARNINGS

Over the years, research carried out at Fundecitrus and partner institutions has led to improvements in recommended management practices. The citrus belt, for example, has been using healthy seedlings since the early 2000s and, as early as 2004, it began to adopt other strategies against the disease, such as high inspection frequency followed by the eradication of affected trees, and chemical control of the vector by spraying at intermediate time ranges. "In addition to these phytosanitary strategies, citrus belt producers have started to anticipate and increase production through more intensive crop practices, such as planting densification, nutrition, irrigation, and simultaneously addressing canopy and rootstock, which have increased the yield

rate. These approaches have become more widely adopted as we were able to deeply understand the dynamics of greening and the demands imposed by the disease on citrus growers," explains Fundecitrus researcher, Renato Bassanezi.

As such, research has become more robust in several fronts, all aimed at devising the best strategy for inspecting and eradicating diseased plants, evaluating the effectiveness of contact and systemic insecticides, as well as determining the best application method, timing, and interval between sprayings, as measures to reduce psyllid incidence and bacteria transmission. Management based on the three pillars was also recommended and initiated in Florida, but only the use of healthy seedlings worked well. The region had just gone through the massive eradication campaign against

citrus canker, which discouraged producers from eradicating more plants. Consequently, heavier support was given to controlling the psyllid, increasing the frequency of spraying, biological control, and natural barriers, with little eradication of diseased plants. "However, these isolated methods have not proven to be efficient and, in conjunction with the remaining contaminated plants in groves, the underestimated flight capacity of psyllids, and

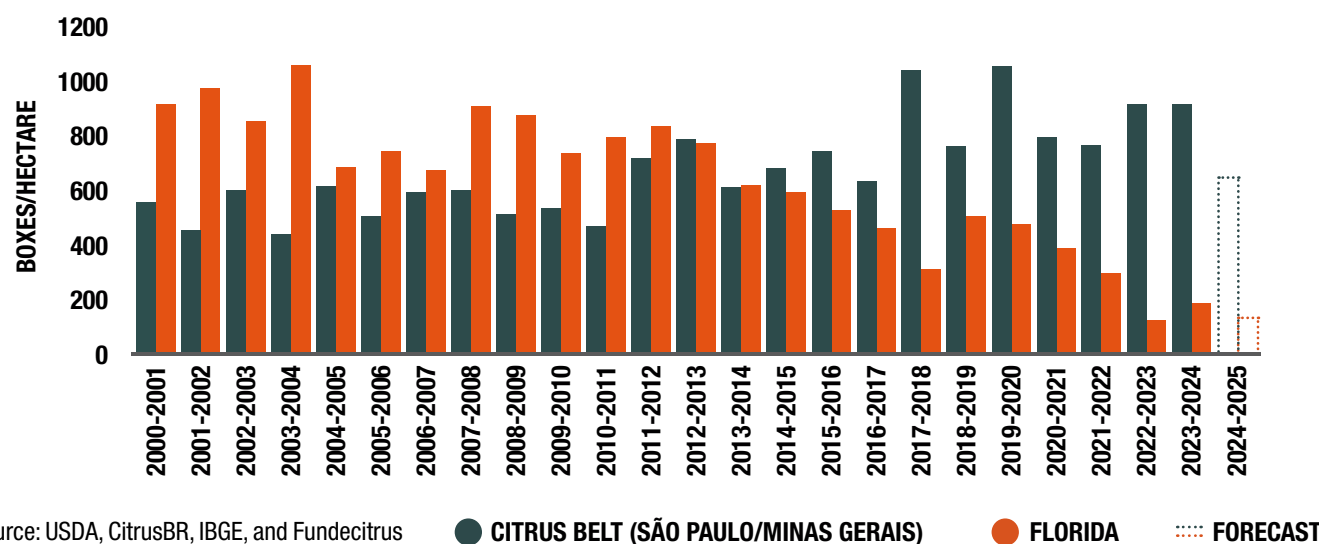
THE SECTOR'S COMPLIANCE TO THE MANAGEMENT RECOMMENDED BY FUNDECITRUS FOR CONTROLLING GREENING AND PSYLLIDS WAS CRUCIAL IN PREVENTING DEVASTATION BY THE DISEASE IN THE BELT

the highly efficient bacterial acquisition and transmission of the insect, the disease spread rapidly in the American state," concludes Bassanezi.

Several measures for curing infected plants or mitigating the damages of greening, such as pruning symptomatic branches, thermotherapy, enhanced nutrition, potential resistance inducers, antimicrobial peptides, and others, were tested by producers in Florida and São Paulo, but they were not able to prevent the production collapse in groves that did not remove the sick plants. "Currently, measures such as antibiotic injection and spraying of plant growth regulators have shown some effect in improving the conditions of diseased plants, but it is still unknown if they will be sufficient for Florida's citrus industry to relive its golden age of productivity," he explains.

YIELD

In the citrus belt of São Paulo and the West-Southwest of Minas Gerais, productivity increased even after the identification of the disease in 2004



Source: USDA, CitrusBR, IBGE, and Fundecitrus

● CITRUS BELT (SÃO PAULO/MINAS GERAIS) ● FLORIDA FORECAST

REGIONAL MANAGEMENT, A MILESTONE FOR DISEASE CONTROL

In 2010, Fundecitrus research on citrus greening set a key direction for the development of regional greening management. This approach was based on the Phytosanitary Alert (now renamed as Psyllid Alert), which tracks sprouting incidence and psyllid capture in traps of monitored regions, along with the adoption of actions to reduce inoculum in external areas of properties. In addition to the management carried out within commercial properties, citrus farmers, in partnership with Fundecitrus, started eliminating bacteria-hosting plants by adopting spraying in abandoned groves and releasing parasitoids against the psyllid (*Tamarixia radiata*) in non-commercial properties around the farms. Furthermore, the spraying frequency was

adjusted for chemical control of the vector based on the plant's sprouting period, establishing as a rule the rotation of insecticide action modes to prevent psyllid resistance. More recently, citrus growers have integrated the use of kaolin as a repellent along with the planning of new groves in more isolated, low-incidence areas, bearing in mind the size and shape of the property and of the plots, planting direction, and size of the edge strip. These actions have been paramount in considerably reducing the disease inoculum and dissemination, whose objective is to buy more time to advance the research focused on more sustainable alternative strategies for controlling greening, such as the use of biotechnology.

OTHER FACTORS

In addition to the different greening management methods in the two regions, geographical factors, such as neighboring areas and climate, also contributed to the reduction in area, production, and yield rate in Florida. The Brazilian citrus belt has geographical advantages due to the possibility of expansion and migration to new areas within the same state or even to neighboring states, which is not possible in Florida, as it is a swampy peninsula.

The climate is another factor that also needs to be considered for understanding the stable level of productivity in the belt. "Both regions

face climate challenges, but hurricanes and frosts in Florida have proven more damaging to production in recent years than droughts and heatwaves in the citrus belts of São Paulo and Minas Gerais states," explains Bassanezi. With the lack of land to migrate and poor greening management, Florida reached 80% of sick plants as early as 2012. In the same year, the citrus belt had only a 7% incidence.

In Ayres' opinion, the battle against greening is a daily exercise that has been understood by Brazilian citrus farmers over the years. "The science built by Fundecitrus is of no use if it is not put into practice by those who handle the groves on a daily basis, the citrus growers.

It is a relationship of trust that requires dedication from everyone. So far, the results have been quite good, considering the complexity of greening. We would have a citrus industry severely affected by this disease if it weren't for the work of the entire sector," he emphasizes. Biotechnology is the current focus of efforts driven by Fundecitrus. Insect-repellent plants, combined with edge barriers that attract and kill the psyllid, should further mitigate the incidence of the disease. "The future of citrus farming lies in biotechnology. As long as there is no cure, we will continue to fight to curb the disease, just as we did with CVC in the 1990s," he concludes. 🍊

Benefits of orange juice for intestinal health

A STUDY CONCLUDED THAT BIOACTIVE COMPOUNDS FOUND IN VALENCIA AND MORO ORANGES HELP BALANCE THE INTESTINAL MICROBIOTA OF INDIVIDUALS WITH OBESITY AND INSULIN RESISTANCE

It is well known that Brazil is the world's largest producer of orange juice. In addition to the economic importance that drives the sector, generating employment and income, orange juice is also rich in nutrients, vitamins, and bioactive com-

pounds that offer several health benefits. Ongoing studies, conducted in partnership with Fundecitrus, seek to further understand the positive impacts of this beverage on the human body.

One of these studies was conducted by researchers of the Food Research Center (Forc) at the School of Pharmaceutical Sciences of the University of São Paulo (USP), which found that regular consumption of orange juice can bring significant benefits to the intestinal microbiota of individuals with obesity and insulin resistance. The intestinal microbiota is a set of microorganisms

(bacteria, viruses, and fungi) that inhabit the human intestine and have a significant influence on metabolic processes, the immune system, the production of vitamins, and on some substances that promote good intestinal function, helping to prevent the onset of diseases.

The researchers at Forc observed that the intake of orange juice provided a positive change in the intestinal microbiota profile of the studied population, as well as effects on the digestion and metabolism of bioactive compounds of the fruit, which are related to the reduction of inflammatory processes. The nutritional composition and the presence of specific compounds in the juice promoted antioxidant and anti-inflammatory actions that can trigger potential effects in reducing the risk of various chronic diseases, such as obesity and diabetes.



READ MORE ABOUT THE STUDY CONDUCTED BY FORC (USP) IN PARTNERSHIP WITH FUNDECITRUS



DIET

Many factors are involved in the onset and persistence of obesity, including an imbalance in the composition of the intestinal microbiota that contributes to increased susceptibility to this disease, systemic inflammation, and the development of metabolic dysfunctions. The Forc researcher, Aline Alves de Santana, emphasizes that the diet is one of the key factors influencing microbiota composition. "A diet rich in fresh foods, such as fruits, vegetables, and greens, is related to a healthier and better-balanced intestinal microbiota. This explains researchers' interest in evaluating the effect of different bioactive compounds of foods and their biological activity. Other research projects had already been conducted with healthy individuals. Therefore, we selected these patients who generally have significant alterations in the intestinal microbiota," the researcher explains.

THE STUDY

The study conducted to understand the impact of orange juice intake on the intestinal ecosystem followed 23 volunteers with different degrees of obesity for two months. During this period, the effects of consuming Pera and Moro orange juice were evaluated. The latter has red pulp and juice and is known as blood orange - rich in flava-

nones and anthocyanins, which are anti-inflammatory and antioxidant bioactive compounds found in citrus fruits. The participants consumed 400 ml of natural orange juice, divided into 200 ml servings, twice a day. For 15 days, they received juice from a single orange variety. After this period, the volunteers refrained from drinking any juice for 40 days to avoid interfering with the outcome of the second test. Then, for another 15 days, they

drank the juice of another orange variety.

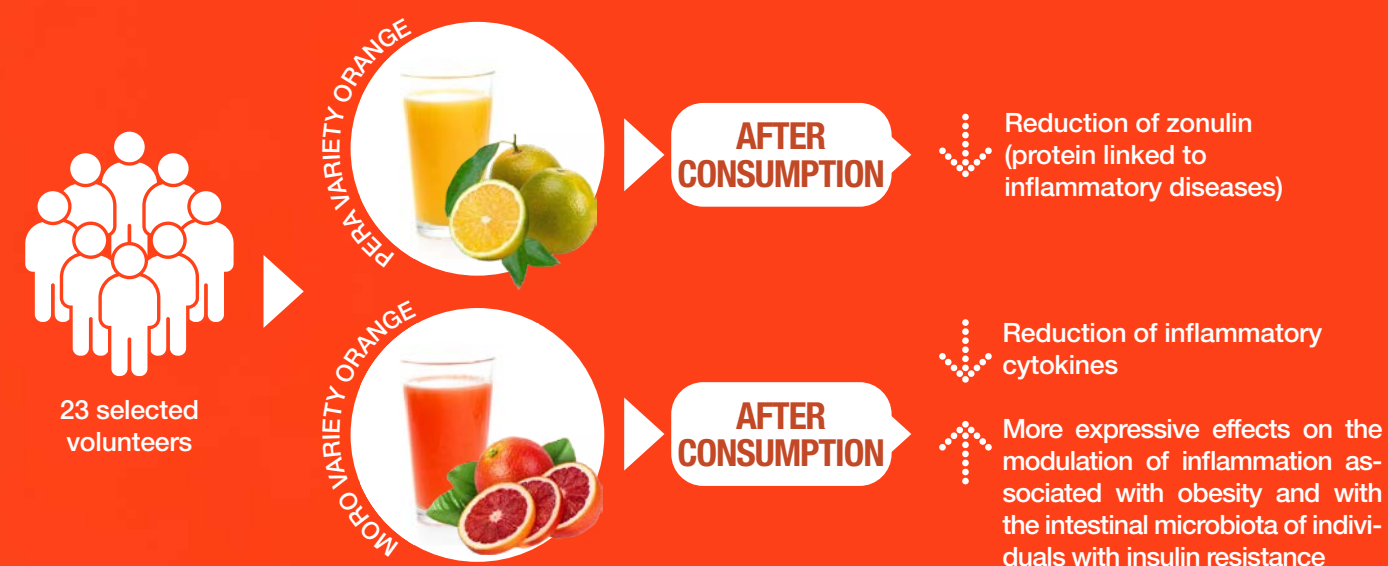
The results were evaluated through the analysis of blood and feces samples from the volunteers, before and after the intervention, respecting each individual's characteristics. Our volunteers had different degrees of obesity and possibly differences in terms of their metabolic and inflammatory profile, and of their intestinal microbiota composition, which could influence the results found in the interventions that were conducted. For this reason, in order to



Aline Alves de Santana, researcher at Forc (University of São Paulo) and study coordinator

HOW THE RESEARCH WAS CONDUCTED

Consumption of 200 ml of orange juice twice a day, for 15 days for each variety:



TEN YEARS OF RESEARCH FOR THE BENEFIT OF CITRICULTURE

Throughout Fundecitrus' 47 years of operation, many institutions and universities have contributed to the development of research for the benefit of Brazilian citriculture. One of these institutions is the School of Pharmaceutical Sciences of the University of São Paulo (USP), which has conducted important studies related to the health benefits of orange juice. The senior professor at USP and lead researcher of Forc, Franco Lajolo, recalls that the partnership began with a proposal to promote research on the effects of orange varieties and their healthy components. "The partnership with Fundecitrus is a successful example. From the inception of the project, we have had a close collaboration and, alongside the projects led by Forc, the Center for Research, Innovation and Dissemination (CEPID), and Fapesp, we have built a fundamental support network for research development," he explains. Over these ten years of partnership, the

results have been promising regarding the effects of juice consumption on human metabolism, lowering of blood pressure, intestinal microbiota, insulin production regulation, glycemic control, among many other research lines and their outcomes. "The information obtained through these clinical trials has helped us establish scientific foundations for future research. Moreover, we need to broaden the trials in order to include epidemiological work," explains the Professor. In the opinion of the researcher and coordinator of the Fundecitrus Biotechnology and Diagnostics laboratory, Nelson Wulff, the partnership has been extremely fruitful. "This work has yielded relevant health discoveries. The partnership between institutions and researchers contributes not only to the research field, but also to society, which stands to benefit from the discoveries of the various ongoing research projects," states Wulff.

deepen the understanding of the effects of orange juice on different degrees of obesity, we evaluated the volunteers according to their degree of obesity and proposed treatment," explains the researcher.

According to the study, the results were significant with both orange varieties. The effects were associated with the presence of hesperidin and narirutin, two important flavanones, and of anthocyanins, found only in the Moro variety orange juice. These bioactive compounds, along with other nutrients, can affect the composition of the gut microbiota and drive beneficial changes as a result of the frequent consumption of oranges.

The researcher explains that the interaction between these compounds was essential for the release of metabolites, a byproduct of flavonoids, which are residues that remain after the body has used the nutritious content of food. These elements play an important role in preventing chronic diseases in individuals with obesity. "The volunteers who consumed the beverage during this period showed significant results in reducing inflammation biomarkers, which also contributed to positive effects on the intestinal microbiota and reducing the risk of obesity-related complications," he emphasizes.

CONCLUSION

The researchers' conclusion, based on clinical trials, is that the consumption of juice from these two varieties presented important and distinct benefits. The Pera orange showed positive actions on intestinal permeability (decrease in zonulin protein), while the Moro variety orange juice promoted more significant effects on modulating inflammation associated with obesity and on the composition of the intestinal microbiota of individuals with obesity and insulin resistance. All the work was coordinated by the professors Forc Franco Lajolo and Neuza Hassimoto, as well as by other researchers of the center. 🍊



Franco Lajolo and Neuza Hassimoto, researchers at Forc (USP)

Fundecitrus
SCIENCE AND SUSTAINABILITY
IN CITRICULTURE

47 years of history and dedication
to Citriculture in Brazil



RECOGNIZE

CITRUS GROWER-FRIENDLY COMPANY



Citrus Grower-Friendly Companies encourage actions to control pests and diseases and the dissemination of Fundecitrus information.

