

## CURRENT SITUATION, MANAGEMENT AND ECONOMIC IMPACT OF CITRUS CANCKER IN SÃO PAULO AND MINAS GERAIS, BRAZIL

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### Abstract

Citrus canker was first reported in Brazil in 1957, in Presidente Prudente County, São Paulo State. Since then an eradication program was started and quarantine efforts have been applied. After the introduction of citrus leafminer (*Phyllocnistis citrella*, Stainton), in 1996, a higher number of citrus canker foci was observed and, as a consequence, the eradication methodology was changed in 1999 by a State law. In São Paulo State, the Citrus Canker Eradication Program (CCEP) is a joint effort between the Federal and State Governments and the citrus growers. To find contaminated groves in the State, Fundecitrus makes an annual survey of all trees of 10% of the commercial blocks (with more than 199 citrus trees). Based on the distribution of contaminated groves in the State, the CCEP determines the inspection actions in each citrus production area. Depending on contamination incidence, all citrus blocks of some counties are inspected more than once a year. Inspections made by citrus growers are another way to find contaminated citrus trees in commercial blocks. Inspections by Fundecitrus are done also in citrus nurseries and urban areas. Contaminated citrus blocks are simultaneously observed by three teams of inspectors. When there are more than 0.5% of infected trees, all trees in the block, infected and non-infected, are eradicated. If less or equal to 0.5% of infected trees are detected, the infected trees and the non-symptomatic trees, in 30 meters of radius, are eradicated. There are quarantine restrictions and replanting in the eradicated area is prohibited up to two years after eradication. New inspections are done periodically in the eradicated area during the quarantine period. From January 1999 to December 2008 a total of 4,393,230 citrus trees were eradicated in commercial blocks, 2,327,772 in citrus nurseries, and 1,178,518 in non-commercial blocks. In the last ten years the impact of citrus canker represented about 476 million dollars, considering the costs of inspections by Fundecitrus and growers, and field and nursery trees elimination. After 1999, the current CCEP has maintained the incidence of contaminated commercial citrus blocks between 0.08 and 0.27% (0.17% in 2008). Weather conditions and number of inspections (number of inspected trees) are the most important factors that affect the efficacy of citrus canker eradication in the State.

### Introduction

In Brazil, citrus canker was first reported in 1957, in Presidente Prudente County, São Paulo State (SPS) (Amaral, 1957; Bitancourt, 1957). The decision of SPS government to establish the Citrus Canker Eradication Program (CCEP) occurred soon after its discovery, because of the disease's aggressive spread and the history of eradication in other countries such as the USA (Santos, 1991). In the initial eradication campaign in Brazil, the procedure was to remove of all citrus canker symptomatic trees and all trees within a 12 meter radius of the symptomatic ones. After the beginning of the campaign in 1957, the disease was found in many municipalities of the Alta Sorocabana region and other measures were attempted to eradicate the pathogen: the establishment of new citrus plantations and citrus nurseries were forbidden in 29 municipalities, all citrus nurseries infected or not were eliminated in the same region, the movement of citrus fruit and citrus trees from any infected municipality was forbidden. Moreover, a campaign to raise awareness about the presence of citrus canker in the State was conducted. Despite the measures taken, new cases of the disease continued to be reported and it was decided to remove of all citrus trees in the municipalities included in the CCEP. This action, executed by the

SPS government, continued until 1961, involving the inspection of 11,000 farms in 21 municipalities and the elimination of 1.2 million trees (Santos, 1991).

After 1962, the actions of SPS government were extended to other regions of the state because new foci of citrus canker were identified in new municipalities. In this second phase of CCEP the methodology of eradication was revised and a 1,000 meters radius was adopted. In 1966, the *Instituto Biológico* in SPS was in charge of the CCEP under the *Coordenadoria de Assistência Técnica Integral* (CATI). This new eradication protocol remained in effect until 1975, when the federal National Campaign of Citrus Canker Eradication (CANEEC), was created. The national campaign was conducted to eliminate the pathogen throughout Brazil and implemented through state committees from São Paulo, Paraná and Mato Grosso do Sul. In 1977, the CANEEC requested the participation of SPS citrus growers in the CCEP and Fundecitrus was created (Santos, 1991). Presently, Fundecitrus functions throughout SPS and in the South of Triângulo Mineiro in Minas Gerais State, in the conduct of all actions involving citrus plant protection. Fundecitrus performs the CCEP jointly with the Secretary of Agriculture in SPS and Minas Gerais State.

Even though the CCEP was extended to other regions and states in Brazil, the disease continued to spread into more SPS municipalities and other states (Barbosa et al., 2001; Gimenes-Fernandes et al., 2000; Rossetti, 1977; Santos, 1991). In 1979, the first case of citrus canker was detected in the traditional citrus growth region so called “exportation citrus zone”, initially in the municipality of Monte Alto and later in the municipality of Cândido Rodrigues. Further surveys confirmed the presence of the disease in other municipalities in the “exportation citrus zone”, including Taquaritinga, Araraquara, São José do Rio Preto and Itápolis (Santos, 1991). Although there were many new foci, the protocol for eradication was relaxed in 1987, when the radius of eradication changed to 50 meters, and further relaxed in 1995, with reduction of the eradication radius to 30 meters (Brasil, 1987; Brasil, 1995). Although, the federal CCEP is valid for all states of Brazil, the eradication efforts were not applied in the southern states (Paraná, Santa Catarina, and Rio Grande do Sul).

SPS has some advantages compared to Florida and other states/countries where citrus canker eradication programs have failed: 1) SPS has had a very low prevalence of citrus canker; 2) Fundecitrus has developed a qualified and economical work force to frequently inspect the groves; 3) there are no legal impediments to slow the eradication process; and 4) there is no catastrophic weather in Brazil, such as tornados and hurricanes, that otherwise could spread the disease over long distances. Nevertheless, a continuous and comprehensive effort must be maintained by the CCEP to prevent the disease from becoming endemic in SPS.

Systematic surveys carried out by Fundecitrus in SPS since 1992 showed that until 1996 the annual average numbers of symptomatic and eradicated trees were respectively 2,705 and 22,077. In the years following, the eradication increased to 299,856 contaminated trees and 2,037,401 eradicated trees in 1999 (Figure 1). Besides a greater number of inspected trees in 1999, this increase of new citrus canker foci coincided with the period after introduction of citrus leafminer (*Phyllocnistis citrella* Stainton) in 1996 (Prates et al., 1996). Damage by citrus leafminer significantly altered the spatial pattern of citrus canker in SPS and increased the spread and development of new infections (Belasque Jr. et al., 2005a, 2005b; Bergamin Filho et al., 2000, 2006; Chagas et al., 2001; Christiano, 2003; Gottwald et al., 1997, 2007). As a consequence of this increase in disease spread, in September 1999, the eradication protocol became more stringent, i.e., the number of trees to be eliminated became depended on the disease incidence in the block. When disease incidence is higher than 0.5%, all trees are removed in the block, whereas when disease incidence is equal to or less than 0.5%, an eradication radius of 30 meters is applied. Additionally, alternative eradication methods, such as drastic pruning or chemical defoliation, are not allowed (São Paulo, 1999).

Currently the CCEP in SPS not only addresses the disease foci in commercial citrus groves, but also foci in non-commercial citrus groves in rural and residential areas, as well as in citrus nurseries.

*Current status of citrus canker eradication in commercial citrus groves*

Beginning in 1999, an annual sampling survey of the entire citrus area in SPS was conducted to estimate the incidence of commercial citrus blocks contaminated with citrus canker. This sampling survey usually is done between March and May, soon after the end of rainy season, to facilitate the detection of diseased trees. Based on the recent occurrence of contaminated blocks, an annual plan for the disease survey is designed. Ten percent of all commercial citrus blocks are chosen by lot to be inspected considering the susceptibility of the four main citrus scion varieties grown in SPS ('Pera Rio', 'Natal', 'Valencia' and 'Hamlin'), the age of trees and the geographic region (North, Northwest, West, Center and South). In each chosen block 100% of the trees are inspected with the aim of determining whether the block is positive for canker or not.

Since 1999, with the application of the latest protocol for elimination of infected and exposed trees, the incidence of contaminated blocks has been significantly reduced and now stands between 0.08% and 0.27%. This validates the efficacy of the CCEP for maintaining the disease under control (Figure 2). The CCEP recognizes that the program is not designed to completely eradicate the disease in SPS, but to suppress the disease to an acceptable level.

The sampling survey also indicates the most affected regions. In 2008, the West and Northwest regions of SPS were the most affected, with 1.59% and 0.49%, respectively, of contaminated blocks, followed by the Central (0.16%), North (0.06%) and South (0.00%) regions (Fundecitrus, 2008).

In the affected regions, a total survey (inspection of all farms and blocks in the area) is applied. This total survey is done to detect all contaminated blocks in rural (commercial and non-commercial) and urban areas. The aim of this total survey in commercial citrus groves is to detect which blocks have diseased trees without the need of localize all diseased trees. This inspection to detect contaminated blocks is called "continuous inspection", because the inspector walks continuously through the row middles observing the trees without stopping to look for canker symptoms on each individual tree. Once a suspect tree is found this kind of inspection stops and a "100% inspection" begins to detect the maximum number of diseased trees in the suspect block. In this case, all trees are inspected by walking around each tree to carefully look for canker symptoms. This 100% inspection is done by three consecutive inspection teams. According to the incidence of symptomatic trees in the affected block, the total or partial removal of the trees is applied. Quarantine restrictions are applied that prohibits replanting in the eradicated area up to two years after eradication. New inspections are conducted periodically in the eradicated area during the quarantine period. Blocks partially eradicated (canker incidence  $\leq 0.5\%$ ) are periodically re-inspected. The first and second re-inspections are done by two inspection teams at 30 days after eradication and 30 days after the first re-inspection. The third and fourth re-inspections are done by one inspection team at 60 days intervals and the other re-inspections are done at 90 days intervals for up to two years after eradication. If in any re-inspection the incidence of new contaminated trees is higher than 0.5%, the entire block is eradicated. If in any re-inspection the incidence of new contaminated trees is equal or less than 0.5%, only the contaminated trees are eliminated by burning. During the re-inspections all blocks of the contaminated farm and neighboring farms are inspected as well. The contaminated block is only considered free of canker after two years from the last detection of a contaminated tree, and after that replanting is allowed.

The efficacy of CCEP can be measured by comparing the number of inspected trees each year and the respective cases of contamination. The rates of eradicated trees/inspected trees in commercial citrus groves are shown in Figure 3. Between 77 and 188 million trees were inspected each year from 1999 to 2008. In spite of the higher number of inspected trees in 1999 (108 million) than in 2000 (93 million), similar rates were observed in both years. Since 2003, the yearly rate has remained about the same: an average of two trees eradicated for each one thousand trees inspected. In 2008, 195,930 commercial trees were eradicated.

*Current status of citrus canker eradication in noncommercial citrus groves and residential areas*

Since 2000, the CCEP also has contemplated inspections of properties in rural areas that do not commercialize citrus fruits but have a substantial number of citrus trees (but less than 200) and in the backyards in urban areas. Although of less economic importance, diseased trees in these locations are an important source of inoculum. After 2003, the inspection of these farms was intensified and after 2005 the number of eradicated trees decreased each year (Figure 4). This indicates the importance of eliminating this noncommercial source of inoculum before it spreads to commercial groves. Through December 2008, 58,569 non-commercial trees were eradicated.

*Current status of citrus canker eradication in citrus nurseries*

Historically, the dissemination of citrus canker has been most highly correlated with the movement of contaminated citrus propagation material. Since 2003, the mandatory state regulations for production of citrus nursery trees in a protected environment (closed nursery), has almost completely eliminated the occurrence of pests and diseases including citrus canker (Figure 5). However, at the beginning of 2006, the detection of canker in plant in closed nurseries was a setback for the CCEP. For the first time, canker was found on new propagations of citrus nursery trees. After this incident, the frequency of inspections of citrus nurseries was increased to monthly inspections of all 530 closed nurseries of SPS. From 1999 to 2008, 2,327,772 plants were eradicated in citrus nurseries. In 2008, only one contaminated citrus nurseries were found and 215,216 nursery trees were eradicated.

*Economic Impact of citrus canker*

It can be estimated the economic impact of citrus canker for SSP considering the amount of money spent on CCEP by Fundecitrus and growers in inspections and the lost of eliminated plants in commercial and non-commercial groves, and also of citrus nurseries. From 1999 to 2008, about US\$ 360 million were spent on Fundecitrus and growers inspections. Considering US\$ 20.00 the price of a citrus tree in the field and US\$ 2.00 the price of a nursery citrus plant, it can be estimated that more US\$ 116 million were lost eliminating infected and exposed trees in the last ten years.

**Conclusions**

Tremendous progress has been made to reduce the incidence of citrus canker to an acceptable level for the SPS citrus industry. Since the beginning of CCEP in 1957 it has never achieved the complete eradication of the pathogen, but the program has produced a high level of grower awareness of the risk of citrus canker spread and potential for the disease to cause crop loss. The CCEP has convinced SPS citrus industry that complete elimination of the pathogen from an affected area can only be accomplished through repeated inspections of citrus in commercial, rural and urban areas, elimination of symptomatic trees and exposed ones, burning of crop wastes, control of weeds and the prohibition of new planting for a period of time.

Citrus growers in SPS understand that they can participate in the prevention of the introduction and spread of citrus canker by taking several steps: 1) planting healthy nursery trees, 2) conducting self inspections, 3) establishing windbreaks to reduce the risk of introduction and dissemination of the pathogen, 4) applying preventive copper sprays to new vegetative flushes in groves that are in proximity to contaminated areas, and 5) practicing decontamination of harvesting ladders, fruit boxes, bags and workers clothes as well as, tractors and other implements used in the groves, and vehicles that enter into the farm.

As part of the CCEP, the educational program from Fundecitrus has continuously provided information and training for citrus grove workers in disease recognition and the measures to prevent the introduction and spread of the pathogen.

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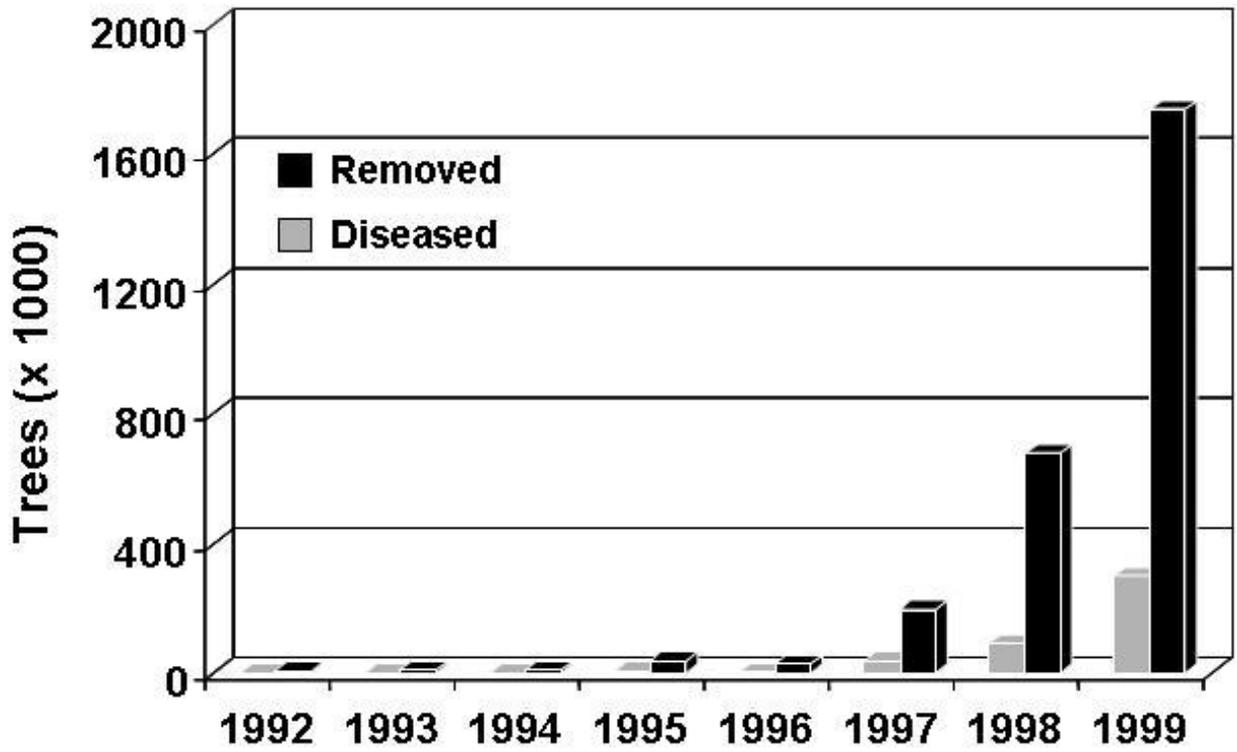


Fig. 1. Number of citrus canker diseased and eradicated trees in the São Paulo State from 1992 to 1999 (Fundecitrus, 2008).

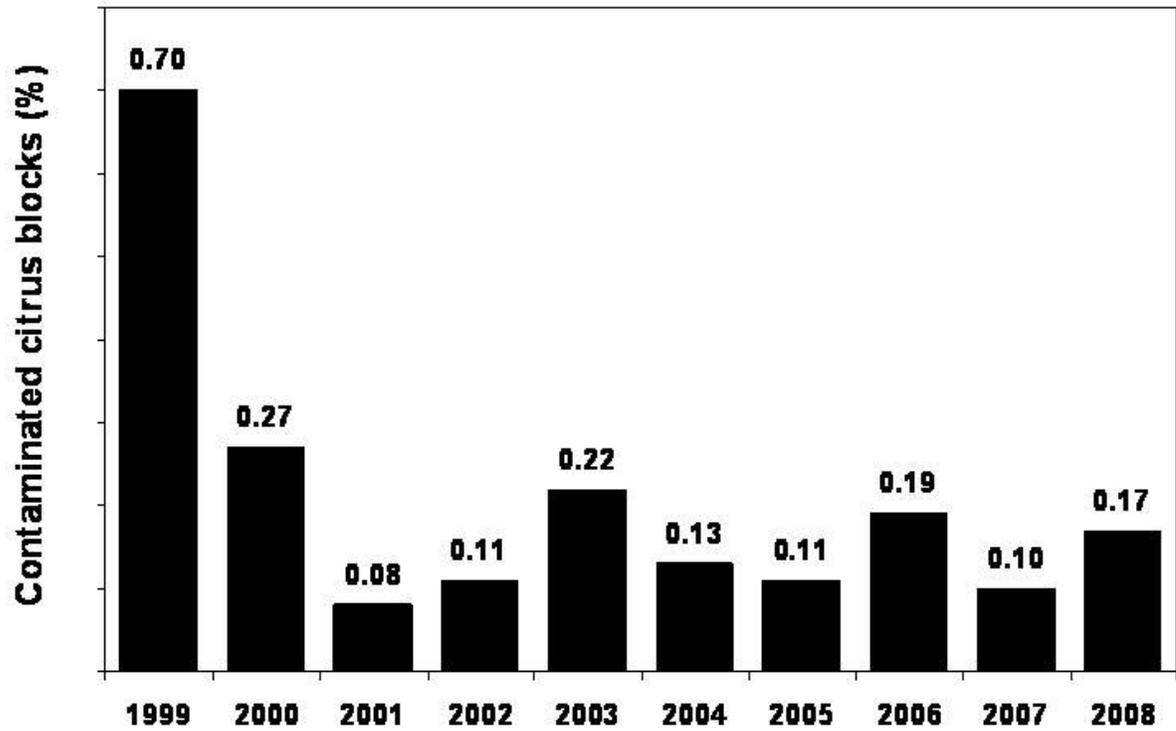


Fig. 2. Incidence of citrus canker contaminated commercial citrus blocks (%) in São Paulo State and the south of Triângulo Mineiro, Minas Gerais State estimated by survey from 1999 to 2008 (Fundecitrus, 2008).

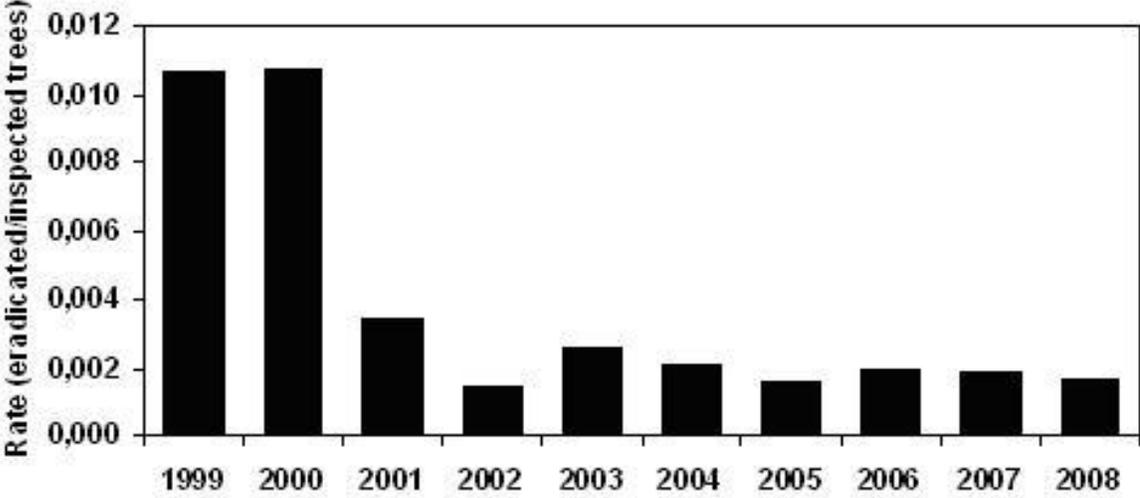


Fig. 3. Rate of citrus canker eradicated trees/inspected trees in commercial citrus blocks in São Paulo State from 1999 to 2008.

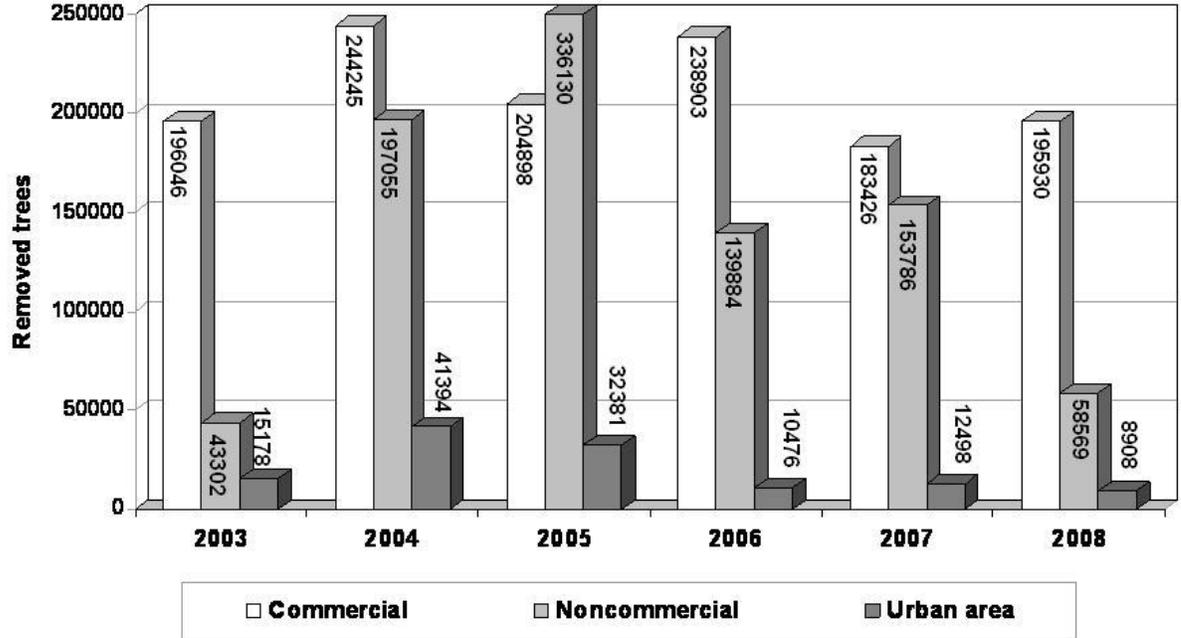


Fig.4. Eradicated trees in commercial and non-commercial citrus farms and in urban areas of São Paulo State and the south of Triângulo Mineiro, Minas Gerais State from 2003 to 2008 (Fundecitrus, 2008).

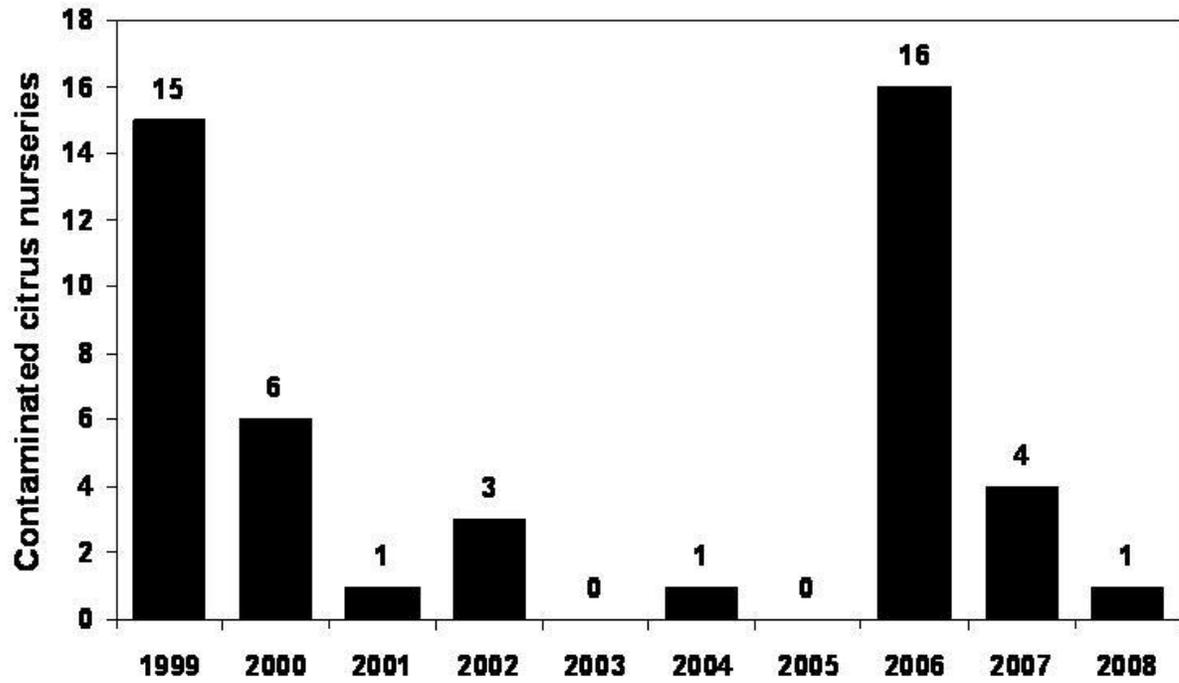


Fig. 5. Number of citrus nurseries with citrus canker in São Paulo State from 1999 to 2008 (Fundecitrus, 2008).