

EPPO Datasheet: *Phyllosticta citricarpa*

Last updated: 2020-06-19

IDENTITY

Preferred name: *Phyllosticta citricarpa*

Authority: (McAlpine) Aa

Taxonomic position: Fungi: Ascomycota: Pezizomycotina:
Dothideomycetes: Botryosphaeriales: Phyllostictaceae

Other scientific names: *Guignardia citricarpa* Kiely, *Phoma citricarpa* McAlpine, *Phyllostictina citricarpa* (McAlpine) Petrák

Common names: CBS, black spot of citrus, freckle spot of citrus, hard spot of citrus, shot-hole of citrus, speckled blotch of citrus, virulent spot of citrus

[view more common names online...](#)

EPPO Categorization: A1 list

[view more categorizations online...](#)

EU Categorization: Emergency measures, A1 Quarantine pest
(Annex II A)

EPPO Code: GUIGCI



[more photos...](#)

Notes on taxonomy and nomenclature

Citrus black spot disease was first described in Australia (Cobb, 1897; Kiely, 1948, 1949a; Chiu, 1955; McOnie, 1964a; McMillan, 1986; Lee, 1969; Kotzé, 1981). The asexual morph (anamorph) of the citrus black spot fungus was described by McAlpine (1899), initially under the name *Phoma citricarpa*, and then called *Phyllosticta citricarpa* (van der Aa, 1973). The sexual morph (teleomorph) was described by Kiely (1948) and designated *Guignardia citricarpa*. According to the new code for fungal nomenclature approved by the International Botanical Congress in Melbourne in July 2011, the dual nomenclature for fungi should not be used anymore ('One Fungus – One Name'), and gives priority to the oldest name irrespective of whether it is teleomorphic (sexual reproduction) or anamorphic (asexual reproduction) (Norvell, 2011). In the case of the citrus black spot pathogen, the name *P. citricarpa* has priority over *G. citricarpa* and should now be used as the only identifier of this species.

In the past, taxonomic confusion has characterized studies about *Phyllosticta*/*Guignardia* species found on citrus. For many years, the coexistence of pathogenic and non-pathogenic strains of *P. citricarpa* has been assumed, as *P. citricarpa* had been detected on asymptomatic citrus trees, as well as on other hosts in Australia and South Africa (Kiely, 1948; Wager, 1952). Based on pathogenicity tests, McOnie (1964a) demonstrated that the non-pathogenic strains belonged to other *Guignardia* species that did not play a role in citrus black spot disease. The non-pathogenic type could be distinguished by its faster growth, colony type, and production of pycnidia and ascocarps in culture, as well as by a wider geographical distribution than the citrus pathogenic type. Meyer *et al.* (2001) suggested that these two types represented distinct species. Baayen *et al.* (2002) used many of the above characteristics, as well as the presence or absence of a mucoid sheath on conidia, and DNA sequence data to show that the two types were distinct species, namely *G. mangiferae* (the widespread non-pathogenic type), and *G. citricarpa* (the citrus black spot pathogen). In subsequent studies about the identity and genetic diversity of *Phyllosticta* isolates (with emphasis on isolates from citrus), it was proposed that *P. capitalensis* (anamorph of *G. mangiferae*) was the name to be used to designate the taxon that is frequently isolated as an endophyte, with a wide host range and geographical distribution (Glienke *et al.*, 2011). Other *Phyllosticta* species have been associated with citrus, but in many cases confirmatory pathogenicity tests and evidence of re-isolation have not been published. Both *P. citriasiana* and *P. citrimaxima* have been isolated from tan spots on pomelo (*Citrus maxima*) fruit from Asia (Wikee *et al.*, 2013, Wulandari *et al.*, 2009). *P. citribraziliensis* has been described from asymptomatic citrus leaves in Brazil (Glienke *et al.*, 2011). In extensive surveys conducted in China, *P. citrichinaensis* has been found in association with leaf and fruit spots of citrus (Wang *et al.*, 2012). Finally, *P. paracapitalensis* and *P. paracitricarpa* have been isolated in Europe from citrus leaves and leaf litter, respectively (Guarnaccia *et al.*, 2017).

Thus, while new knowledge on the *Phyllosticta* species associated with citrus is continuously emerging, the name *P. citricarpa*

is exclusively applied to the fungus causing black spot of citrus.

HOSTS

P. citricarpa is a leaf spotting and fruit-blemishing fungus affecting *Citrus*, *Poncirus* and *Fortunella* and their hybrids. Except for *Citrus aurantium* (sour orange) and its hybrids, as well as *C. latifolia* (Tahiti lime), all commercially grown *Citrus* species are susceptible to *P. citricarpa* (Aguilar-Vildoso *et al.*, 2002; Kotzé, 2000). Milles *et al.* (2019), in a field inoculation test, showed that all mandarin, sweet orange, lemon and papeda types were susceptible; pomelo, lime, and sour orange types expressed immunity; while various different hybrids were susceptible, resistant and immune. *C. limon* (lemon) is particularly susceptible and thus it is usually the first *Citrus* species to show disease symptoms once the pathogen is introduced into a new area (Kotzé, 2000). However, citrus black spot emerged recently in Florida (USA) directly in *C. sinensis* (sweet orange) orchards (Schubert *et al.*, 2012). Late-maturing cultivars of *C. sinensis* were considered more susceptible than early-maturing ones (Timmer, 1999). However, cultivar field trials conducted in Brazil, as well as studies comparing the rate of disease progress, indicated that cultivar reaction to the disease is more linked to the interaction of environmental factors than with the dynamics of fruit maturation (Spósito *et al.*, 2004; Sousa and de Goes, 2010).

In the case of sour orange, *P. citricarpa* was isolated in Brazil from asymptomatic leaves, black spot lesions and other fruit blemishes (Baayen *et al.*, 2002; Wulandari *et al.*, 2009; Wickert *et al.*, 2009; Glienke *et al.*, 2011), although no evidence of reproduction on this citrus species was found. *C. latifolia* (Tahiti lime) is reported not to exhibit citrus black spot symptoms under field conditions, even in areas with high inoculum pressure. However, *P. citricarpa* was isolated in Sao Paulo, Brazil, from asymptomatic fruit and leaves of *C. latifolia* (Baldassari *et al.*, 2008; Wickert *et al.*, 2009). As *P. citricarpa* can colonise and form viable ascospores in *C. latifolia* leaves, this citrus species might be an asymptomatic host which could play a role in *P. citricarpa* epidemiology (Baldassari *et al.*, 2008).

Although it has been reported that *C. maxima* (pomelo) is not affected by *P. citricarpa* (Miles *et al.*, 2013; Wang *et al.*, 2012), more data as well as appropriate pathogenicity tests are needed to completely exclude this citrus species as a potential host of *P. citricarpa*.

With regard to *Fortunella* sp. (kumquat), this species was recorded by Kiely (1948) in Australia as moderately susceptible to *P. citricarpa* under conditions of natural infection, but no further experimental information is available.

No definitive information has been found on the susceptibility of *Poncirus* (trifoliate orange) to *P. citricarpa*.

In early studies, several non-citrus hosts have been reported to harbour *P. citricarpa*: almond (*Prunus dulcis*), avocado (*Persea americana*), cardamom (*Elettaria cardamomum*), *Cola nitida*, *Dioscorea pentaphylla*, *Eucalyptus deglupta*, guava (*Psidium guajava*, *P. montanum*), mango (*Mangifera indica*), passion fruit (*Passiflora edulis*), *Rubus* spp., sugarcane (*Saccharum officinarum*) and a variety of ornamentals such as *Caesalpinia pulcherrima*, *Callistemon citrinus*, *Camellia japonica*, *Dendrobium speciosum*, holly (*Ilex aquifolium*), *Magnolia* sp., *Smilax* sp. (Allen, 1971, FAO, 1960, Hudson, 1962, Kiely, 1948; Kiely, 1949b; McOnie, 1964a, Roy, 1965). However, this list of non-citrus hosts is controversial and doubtful for two main reasons: 1) adequate cross inoculation details are lacking, and 2) on *Camellia*, *Dioscorea*, *Ilex*, *Persea*, *Psidium*, *Mangifera* and *Smilax*, fungal species have been described under the names *Guignardia camelliae*, *G. dioscoreae*, *G. philoprina*, *G. perseae*, *G. psidii*, *G. mangiferae* and *G. smilacis*, respectively.

Host list: *Citroncirus webberi*, *Citrus maxima*, *Citrus medica*, *Citrus reticulata*, *Citrus tankan*, *Citrus x aurantiifolia*, *Citrus x aurantium* var. *paradisi*, *Citrus x aurantium* var. *sinensis*, *Citrus x aurantium*, *Citrus x limon*, *Citrus x limonia*, *Citrus x nobilis*, *Citrus*, *Fortunella*

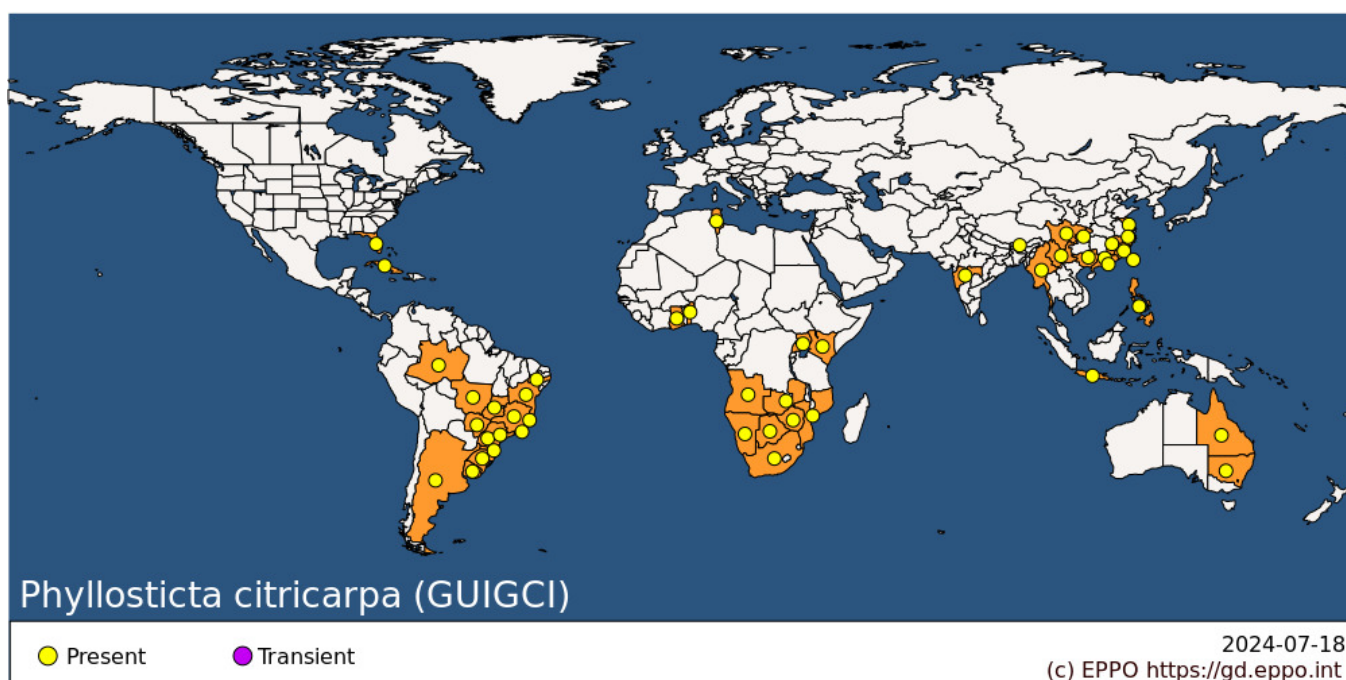
GEOGRAPHICAL DISTRIBUTION

P. citricarpa is thought to originate in south-east Asia. Citrus black spot was first recorded in Australia in 1895 on *Citrus sinensis* (Benson, 1895). The disease has been present for decades in many humid subtropical citrus-producing regions in Africa, Australia, Southeast Asia, and South America (CABI, 2011; Kotzé, 1981; Paul *et al.*, 2005.). In early 2010, *P. citricarpa* was discovered for the first time in the USA, in commercial citrus orchards in

Southern Florida (NAPPO, 2010; Schubert *et al.*, 2012). In 2019, the presence of *P. citricarpa* was officially confirmed in the Mediterranean Basin, in Tunisia (Governorate of Nabeul) where official phytosanitary measures are being implemented to control the disease (EPPO, 2019).

Due to its complex and evolving taxonomy, the geographical distribution of *P. citricarpa* is difficult to establish with certainty. Past records of *Phyllosticta* on citrus in some countries may in fact correspond to the non-pathogenic and morphologically similar species, *P. capitalensis*. The latter being an endophyte commonly isolated from citrus and other hosts, and recorded on all continents (Wikee *et al.*, 2013). For example, *P. citricarpa* has been reported from Mexico and Japan (Stringari *et al.*, 2009), but its establishment is not confirmed by other publications. A record for New Zealand in CMI (1990) refers in fact to *G. mangiferae* (Everett and Rees-George, 2006). Old records in CMI (1990) for Burma, India, Iran, Israel, Korea (Republic of), Lebanon, Malaysia, Pakistan, Singapore, Sri Lanka, Thailand, Vietnam, Egypt, Tanzania, Cook Islands, Niue, Tonga, Western Samoa, Fiji, Hawaii (USA), Papua New Guinea, Georgia, Belize, Honduras, Jamaica, Trinidad, Peru, Vanuatu and Venezuela are most probably misidentifications. The situation in Hong Kong, Swaziland and Nigeria is still unclear. In 2017, Guarnaccia *et al.* reported the finding of *P. citricarpa* in Malta (Gozo and Zurrieq), Italy (Trebisacce) and Portugal (Monchique) however, neither symptoms nor the pathogen have been detected during official surveys in the areas where *P. citricarpa* was been reported by these authors. Current knowledge about the distribution of other *Phyllosticta* species reveals that most of them are present in Asia, where citrus originated (Wu *et al.*, 2018). *P. citrichinaensis*, *P. citriasiana* and *P. citrimaxima* were found only in Asia, and the endophyte *P. citribraziliensis* has been reported only in South America (Glienne *et al.*, 2011; Guarnaccia *et al.*, 2017; Wang *et al.*, 2012; Wikee *et al.*, 2013b; Wulandari *et al.*, 2009).

The countries, states and provinces listed below are locations where *P. citricarpa* is known to be present or where substantial evidence exists that citrus black spot occurs.



EPPO Region: Tunisia

Africa: Angola, Benin, Botswana, Ghana, Kenya, Mozambique, Namibia, South Africa, Tunisia, Uganda, Zambia, Zimbabwe

Asia: Bhutan, China (Chongqing, Fujian, Guangdong, Guangxi, Jiangsu, Jiangxi, Sichuan, Xianggang (Hong Kong), Yunnan, Zhejiang), India (Maharashtra), Indonesia (Java), Myanmar, Philippines, Taiwan

North America: United States of America (Florida)

Central America and Caribbean: Cuba

South America: Argentina, Brazil (Amazonas, Bahia, Espirito Santo, Goias, Mato Grosso, Mato Grosso do Sul, Minas Gerais, Parana, Pernambuco, Rio de Janeiro, Rio Grande do Sul, Santa Catarina, Sao Paulo), Uruguay

Oceania: Australia (New South Wales, Queensland)

BIOLOGY

Life cycle

The natural disease cycle of the pathogen *P. citricarpa* has two infection cycles, a primary cycle driven by ascospores in the leaf litter and a secondary cycle involving pycnidiospores produced on lesions on fruit, twigs and leaves (EFSA, 2014; Guarnaccia *et al.*, 2019). The disease cycle stages include: the start of the ascospore season, the subsequent dynamics of ascospore production, ascospore release, infection by ascospores, production of pycnidia, dispersal of conidia (pycnidiospores) and finally infection by conidia.

Pseudothecia develop 40–180 days after leaf drop, depending on the frequency of wetness and dryness periods, as well as on the prevailing temperatures (Kotzé, 1981). *Citrus* leaves drop all year round in some countries and seasonally in others, and this affects the availability of inoculum. On germination, ascospores produce appressoria with infection pegs that penetrate the cuticle. At their tips, between the cuticle and the upper epidermal cells, the infection pegs produce knots of fungal tissue which are considered to establish latent infection (McOnie, 1967; Kotzé, 1981, Marques *et al.*, 2012).

Pycnidia with conidia (pycnidiospores) are produced on fruit (Kotzé 1981), leaves, dead twigs (Whitesite, 1967; Spósito *et al.*, 2011), fruit pedicels and leaf litter (Kotzé, 2000; Silva *et al.*, 2017; Guarnaccia *et al.*, 2017). They may be dispersed over short distances (less than 80 cm) by washing-down, being responsible for spread of the pathogen within a tree canopy (Kotzé, 1981; Agostini *et al.*, 2006; Spósito *et al.*, 2008, 2011) or inter-canopy (Hendricks *et al.*, 2017). Subsequent studies under laboratory conditions demonstrated that *P. citricarpa* pycnidiospores could reach longer distances than previously thought (Perryman and West, 2014; Perryman *et al.*, 2014). Pycnidiospores on germination enter both unwounded and wounded fruits, and through abrasions caused by hail or insect damage (Kiely, 1949a; Lee, 1969).

The presence of a spermatial state (*Leptodothiorella* state) producing spermatia contained in spermagonia on fallen dead leaves and in pure culture has been recorded as a part of the *P. citricarpa* life cycle, although this state has not been formally described (Baayen *et al.* 2002; Kiely 1948). This state is sometimes referred to in the literature as the 'spermagonial' state and the dumb-bell shaped microconidia as spermatial cells (Kiely, 1949a; Van der Aa, 1973). Kiely (1948) observed that spermagonia always appeared prior to the formation of pseudothecia and hypothesised that spermatia were functioning as male gametes to fertilize a female organ of *P. citricarpa*. However, little is known about the role of spermatia of *P. citricarpa*, since they are incapable of germinating and forming colonies on media.

Tran *et al.* 2017 demonstrated that *P. citricarpa* is heterothallic and requires isolates of different MAT idiomorphs to be in direct physical contact, or for spermatia to fulfill their role as male elements to fertilize the receptive organs, in order to initiate the mating process. The heterothallic nature of *P. citricarpa* was recently confirmed through full sequencing of target loci, showing the presence of separated MAT1-1 or MAT1-2 idiomorphs (Amorim *et al.*, 2017; Wang *et al.*, 2016).

Epidemiology

The epidemiology of citrus black spot is influenced by the availability of inoculum, the occurrence of environmental conditions favourable for infection (i.e. warm, wet and humid conditions), the growth stage of the citrus tree and age of the fruit and leaves (Kotzé, 1981, 2000).

The disease has been reported in most of the major citrus-producing countries, mainly in areas with warm climates with summer rainfall (Carstens *et al.*, 2012; Magarey *et al.*, 2015; Martínez-Minaya *et al.*, 2018; Paul *et al.*, 2005; Yonow *et al.*, 2013). Spore production and release occur during the rainy season (Dummel *et al.*, 2015; Fourie *et al.*, 2013; Kiely, 1948; Kotzé, 2000; Reis *et al.*, 2006).

In areas where rain is confined to a single season, pseudothecia with ascospores, produced exclusively on leaf litter, are the main source of inoculum. The optimum temperature for pseudothecial formation is 21–28°C; no pseudothecia are formed below 7°C or above 35°C (Lee and Huang, 1973). Studies from South Africa and Taiwan indicated that maturation of ascospores occurs practically simultaneously in early summer on infected leaves abscised during late

autumn, winter and early spring (Kotzé, 1963; McOnie, 1964b; Lee and Huang, 1973). Ascospore release takes place during rainfall and occasionally during irrigation or when there is heavy dew (Kiely, 1949a; Kotzé, 2000). Ascospores are forcibly released up to a height of 1.2 cm above pseudothecia and are carried by air currents throughout the canopy and over long distances (Kiely, 1949a). Windborne ascospores are generally dispersed under field conditions over longer distances and are associated with the *P. citricarpa* spread between trees (Spósito, *et al.*, 2007). Ascospores were infectious at 15 to 29.5°C and with 15 to 38 hours of wetness (Kiely, 1949a; Kotzé, 1963; McOnie, 1967; Reis, *et al.*, 2006). In Brazil, comparatively low to moderate numbers of ascospores were produced from October to March with peak production in January and February (Reis *et al.*, 2003) while in South Africa, ascospore release occurred mainly from November to March with the highest numbers from December to January (McOnie, 1964b, c).

Where rain is not confined to a single season, where out-of-season fruit with lesions remain on the trees after flowering and fruit set, or where successive and irregular flowering occurs in the cultivated citrus species and varieties, pycnidia with conidia (pycnidiospores) of *P. citricarpa* are also important as inoculum sources (Kotzé, 1981; Spósito *et al.*, 2008, 2011). Under *in vitro* conditions, pycnidiospores of *P. citricarpa* can germinate and form appressoria between 10 and 40°C and 12–48 hours of wetness (Noronha, 2002). In Australia, freshly exuded mature pycnidiospores have been reported to lose their ability to germinate 1 month after they were produced (Kiely, 1949a) however, in South Africa pycnidiospores have been reported to retain their germinative capacity up to 5 months (Wager, 1952).

It has been observed that the pathogen may be present for many years in a region before the disease reaches epidemic proportions. In Mpumalanga province in South Africa, symptoms were present for over three decades before control measures became necessary (Kotzé, 1981). Infection is usually followed by a long period of latency which may last 12–36 months in Australia and about 3–12 months after anthesis for fruit infection in South Africa (McOnie, 1967; Kellerman & Kotzé, 1979). In artificial inoculations conducted under greenhouse conditions, the incubation period ranged from over 200 days for 3-cm-diameter sweet orange fruit to about 50 days for 7-cm-diameter fruit (Aguiar *et al.*, 2012). In field trials carried out in Australia, young fruits inoculated with conidial suspensions after petal fall in October produced black spot disease after nearly 1 year (Kiely, 1949a). In South Africa, young citrus fruits inoculated with high concentrations of conidia in mid-November showed speckled blotch lesions by the end of January the following year (McOnie, 1964e).

Epidemiological studies outside of North America indicate that the most important inoculum for disease spread is ascospores, which are solely produced in decomposing leaf litter under alternating wetting and drying cycles (Kotzé 1981; Reis *et al.*, 2006; Spósito *et al.*, 2008). However, evidence gathered from different parts of the world illustrates the importance of pycnidiospores during the early stages of invasion. At the beginning of the epidemics in Zimbabwe, it was shown that most infections originated from pycnidiospores, while ascospores were only found in very small numbers (Whiteside, 1967). In Argentina, Garrán (1996) indicated that attempts to detect the sexual stage by weekly sampling of dead leaves in plots affected by citrus black spot were unsuccessful. Epidemiological studies conducted in Sao Paulo, Brazil, found an aggregated spatial pattern of citrus black spot-affected trees in the orchard as well as diseased fruit in the canopy, suggesting that splash-dispersed conidia have an important role in this region (Spósito *et al.*, 2007, 2008, 2011), even in the presence of complementary mating types allowing for sexual reproduction through ascospores (Amorim *et al.*, 2017). In Florida, where citrus black spot was first observed in 2010 (Schubert *et al.*, 2012), disease establishment and spread were attributed to pycnidiospores since the population of *P. citricarpa* is clonal and only one mating type (MAT1-2) is present (Wang *et al.*, 2016; Hendricks *et al.*, 2017).

Flowers and fruits are susceptible to infection from anthesis for approximately 4–6 months (Kellerman & Kotzé, 1979) but the first symptoms on fruit do not appear for more than 6 months after fruit set (Baldassari *et al.*, 2006). According to Frare *et al.* (2019), the length of the latent period can be influenced by factors, such as the inoculum concentration and fruit diameter.

DETECTION AND IDENTIFICATION

Symptoms

P. citricarpa causes diverse symptoms such as hard spot, virulent spot, false melanose and freckle spot on fruit and necrotic lesions on leaves and twigs (Kotzé, 1981, 2000).

The presence of *P. citricarpa* on fruit is unlikely to be confirmed based on visual examination alone, since symptoms on fruit are variable in appearance and often resemble those caused by other citrus pathogens (such as *P. citriasiana*, *P. citrichinaensis*, *Diaporthe citri*, *Mycosphaerella citri*, *Alternaria alternata* pv. *citri*, *Septoria* spp., *Colletotrichum* spp.) or by insect, mechanical or cold damage, particularly in the case of freckle spot (Bonants *et al.*, 2003; Snowdon, 1990; Wang *et al.*, 2012; Wulandari *et al.*, 2009).

The following four types of symptoms are widely recognized as associated with *P. citricarpa* and have been described by Kiely (1949a, 1949b, 1960):

Hard spot: the most typical symptom of citrus black spot, characterised by sunken, pale brown necrotic lesions, 3–10 mm in diameter, with a dark reddish-brown raised border, often containing pycnidia. A yellow halo, when the fruit is green, or a green halo, when the fruit is yellow or orange, may appear around these lesions. Hard spot usually appears when fruit starts maturing, even before colour change, and on the side of the fruit most exposed to sunlight (Kotzé, 1981, 2000).

Freckle spot: cracked or speckled spots, grey, tan, reddish or colourless, 1–3 mm in diameter, slightly depressed at the centre, with no halo around them and almost always devoid of pycnidia. Freckle spots mostly develop after the fruit has changed colour (Bonants *et al.*, 2003).

False melanose or speckled blotch: usually appears on green fruit as small, raised, dark brown to black lesions, often surrounded by dark specks (FUNDECITRUS, 2005). The lesions are devoid of pycnidia and may coalesce as the season progresses (CABI, 2019). This symptom is observed in citrus-growing areas where *P. citricarpa* has been present for a long time and when infections occur in young fruit (FUNDECITRUS, 2005; Frare *et al.*, 2019).

Virulent spot, spreading spot or galloping spot: sunken necrotic lesions without defined borders mostly on mature fruit. Numerous pycnidia eventually develop in these lesions under conditions of high humidity (Kotzé, 2000). Virulent symptom, because, unlike the other symptoms, it extends deeply into the mesocarp (albedo), occasionally involving the entire thickness of the rind, causing premature fruit drop and serious postharvest losses (Kotzé, 1981).

Two additional types of symptoms have also been reported to occur infrequently on citrus fruit: *lacy spot*, superficial yellow lesions with a dark yellow to brown centre, a smooth texture and no defined margins (Aguilar-Vildoso *et al.*, 2002) and *cracked spot*, superficial slightly raised dark brown to black lesions, variable in size, with a cracked surface and irregular margins (Goes *et al.*, 2000).

Leaf and twigs symptoms rarely occur on orange, mandarin and other commercial citrus species, but they are frequently present on lemons. They appear as round, small, sunken necrotic lesions with a yellow halo (Kotzé, 1981).

Morphology

The following morphological and morphometric characteristics refer to fructifications and spores of *P. citricarpa* produced mainly in culture; they are based on data from Sutton and Waterston (1966) and van der Aa (1973), as revised and amended by Baayen *et al.* (2002).

Pycnidia produced on fruit, attached leaves, dead twigs and leaf litter as well as in culture are solitary or occasionally aggregated, globose, immersed, mid- to dark brown, and 70–330 µm in diameter. They contain aseptate, hyaline conidia, multiguttulate, 9.4–12.7 µm × (5.0–8.5) µm, with a colourless subulate appendage and a barely visible, colourless, gelatinous sheath <1.5 µm thick.

The sexual morph presents erumpent, globose to pyriform ascomata, often irregularly shaped, unilocular and with a central ostiole. Asci are eight-spored, bitunicate, clavate to broadly ellipsoid, with a wide, obtusely rounded or slightly square apex. Ascospores are ellipsoid to limoniform, sometimes slightly elongated, aseptate, hyaline, swollen in the middle, slightly curved, 12–16 µm × 4.5–6.5 µm, showing a large central guttule and a mucoid cap at both ends. Spermatia produced both on hosts and in pure culture are hyaline, aseptate, cylindrical to dumbbell-shaped with guttules at each end, 5–8 µm × 0.5–1 µm.

Detection and inspection methods

Identification of *P. citricarpa* is difficult. The distinction between this and similar species based on morphological examination is very difficult and additionally most of the molecular tests available are not specific to *P. citricarpa*. Several of the tests available are described below and these should be combined as recommended in the the EPPO Standard PM 7/17 to have a reliable identification (EPPO, 2020).

Phyllosticta species from citrus requires isolation of the slow-growing fungus and comparison of several traits (cultural and morphological characteristics). For isolation and culturing of the fungus the following media are usually used: cherry decoction agar (CHA), potato dextrose agar (PDA) or PDA amended with 50 µg/mL penicillin and 50 µg/mL streptomycin, oatmeal agar (OA) and malt extract agar (MEA). *P. citricarpa* colonies grow slowly on CHA (Baayen *et al.*, 2002) and usually produce a yellow pigment on OA that diffuses into the medium around the colony. Proof of pathogenicity requires inoculation of fruit or leaves and an incubation period of weeks or months before symptoms appear (Kotzé, 2000). Discrimination between *P. citricarpa* and other *Phyllosticta* species based on morphological features is difficult, time consuming and requires considerable taxonomic expertise, hence a range of molecular tests have been developed to distinguish *P. citricarpa* from other species present on citrus fruits.

Bonants *et al.* (2003) developed a PCR-based detection method. Stringari *et al.* (2009) used random amplified polymorphic DNA (RAPD) markers to develop specific primers for the identification of *P. citricarpa* with PCR. Gent-Pelzer *et al.* (2007) developed a TaqMan PCR method for the diagnosis of *P. citricarpa* on citrus fruit which was more sensitive than conventional PCR, while Hu *et al.* (2014) used quantitative polymerase chain reaction (qPCR) tests based on internal transcribed spacer (ITS)-1 genes for detection and quantification *P. citricarpa* and *P. capitalensis* in leaf litter samples. A real-time PCR test specific for *P. citricarpa* which did not amplify *P. citriasiana* or *P. capitalensis* DNA, was designed by Schirmacher *et al.* (2019). Several studies have been performed with multigene sequencing of a large number of *Phyllosticta* species (Glienke *et al.*, 2011; Wang *et al.*, 2012; Wulandari *et al.*, 2009). Species-specific primers were used to amplify the internal transcribed spacer region (ITS) (de Hoog & Gerrits van den Ende, 1998; White *et al.*, 1990; Guarnaccia *et al.* 2017), part of the translation elongation factor 1- α gene (*tef1*) (Carbone & Kohn, 1999; O'Donnell *et al.*, 1998; Guarnaccia *et al.* 2017), part of the actin gene (*actA*) (Carbone & Kohn, 1999; Guarnaccia *et al.* 2017), the 28S large subunit nrDNA (LSU) (Moncalvo *et al.*, 1995; Vilgalys & Hester, 1990; Guarnaccia *et al.* 2017), the RNA polymerase II second largest subunit (*rpb2*) (Sung *et al.*, 2007; Liu *et al.*, 1999; Guarnaccia *et al.* 2017) and glyceraldehyde-3-phosphate dehydrogenase (*gapdh*) (Myllys *et al.*, 2002; Guerber *et al.*, 2003; Glienke *et al.*, 2011; Guarnaccia *et al.*, 2017). A multilocus phylogenetic analysis, using partial DNA sequences from genes encoding the above loci, was carried out on many *Phyllosticta* species (Sanders *et al.*, 2003; Guarnaccia *et al.*, 2017).

In addition to improved methods for laboratories (e.g. high throughput qPCR), in recent years a lot of research has been focused also on improved methods for inspection services in the field (e.g. Lateral Flow Devices and LAMP methods). As an aid to visual inspection of symptoms, Tomlinson *et al.* (2013) have developed a method for detection of *P. citricarpa* using loop-mediated isothermal amplification (LAMP) which can be used to test black spot lesions, including those lacking pycnidia.

Guidance on the detection and identification of *P. citricarpa* can be found in the EPPO Standard PM 7/17 and ISPM 27 (EPPO, 2020; FAO, 2016).

PATHWAYS FOR MOVEMENT

Natural spread of *P. citricarpa* is mainly ensured by its airborne ascospores over short distances. Conidia (pycnidiospores) produced on fruit, leaves, dead twigs, fruit pedicels and on leaf litter may be also dispersed over short distances (less than 80 cm) by washing-down or rain splashed, being responsible for spread of the pathogen within a tree canopy (Kotzé, 1981; Agostini *et al.*, 2006; Spósito *et al.*, 2008, 2011) or inter-canopy (Hendricks *et al.*, 2017).

Over long distances, the pathogen is very likely to be spread with human assistance by the international trade of citrus fruit and plants for planting (if not prohibited). Current knowledge about the distribution of *Phyllosticta* species reveals that most of them are present in Asia, where citrus originated (Wu *et al.*, 2018). In addition, MAT genotyping of populations demonstrates that several incursions have occurred along with the global establishment of citrus cultivation and given the long-range dispersal of these species via infected citrus plant propagation material (Amorim *et al.*, 2017; Carstens *et al.*, 2017; Guarnaccia *et al.*, 2017; Hendricks *et al.*, 2017; Tran *et al.*, 2017; Wang *et al.*

l., 2016; Zhang *et al.*, 2015). The ‘plants for planting’ pathway from a citrus production area where both mating types occur would be in general the most likely route of introduction for both mating types, as the plant will be a persistent source of inoculum and sexual ascospores can be produced on the citrus leaves in the leaf litter.

In the EPPO region, *P. citricarpa* is regularly intercepted on citrus fruit imports from countries where citrus black spot occurs (Europhyt). However, it is generally considered that the risk of transferring *P. citricarpa* from infested fruit to citrus plants is relatively low (EFSA, 2014). Citrus fruit will be more likely to introduce a single mating type clonal genotype of *P. citricarpa*, compared to an infected plant for planting. This is because *P. citricarpa* only reproduces on fruit through asexual pycnidiospores (Kotzé, 2000). More recently, Tran *et al.* (2017) suggested that only one mating type is present in a single disease lesion in the above ground parts. Moreover, fruit is short-lived compared to an infected plant and so the chance of an infection establishing by splash dispersal from a single lesion of a transient fruit would be lower. In addition to that, citrus black spot lesions on fruit or discarded peel segments have a very low reproductive potential (Korf *et al.*, 2001; Schreuder *et al.*, 2018; Schutte *et al.*, 2014).

PEST SIGNIFICANCE

Economic impact

In most of its current distribution, *P. citricarpa* is reported to cause severe quality and yield losses to citrus fruit production. Several symptoms including hard spot, virulent spot, and false melanose occur on the rind of affected fruit, reducing its commercial value for the fresh market (Kotzé, 2000). Premature fruit drop due to *P. citricarpa* causes significant yield loss in Brazil, and probably in other citrus regions of the world (Reis *et al.*, 2006; Spósito *et al.*, 2011; Araújo *et al.*, 2013).

In the Windsor and Hawkesbury River areas of Australia in 1931, all orchards of sweet orange cvs Washington Navel, Joppa and White Siletta were severely affected and losses of 80% were common in individual orchards (Kiely, 1960). Before the adoption of control measures, heavy losses in sweet orange cv. Valencia had been reported in the coastal orchards in New South Wales (Kiely, 1949a; 1949b). In South Africa 90% of fruits from unprotected trees were claimed to be unfit for export (McOnie, 1964b) and losses of more than 80% of unprotected fruits were reported to be common (McOnie, 1964d). The apparent absence of severe impact at specific locations, e.g. in Addo, Eastern Cape, South Africa, where the pathogen is reported to ‘*persist but not flourish*’ (Yonow *et al.*, 2013), could be due to the relatively recent emergence of the disease, as well as to the fungicide schedules currently in place.

Citrus black spot is expected to affect mainly lemons and late-maturing sweet orange and mandarin varieties, with moderate negative consequences for the production of fresh fruit. There would be a potential for reduction in disease incidence by chemical treatments, but this would cause environmental impacts because in most European and Mediterranean countries fungicides are not widely applied, and the most effective fungicide products are not currently registered for use in citrus. In addition, to export citrus fruit to areas where *P. citricarpa* is regulated, additional fungicide treatments in the orchards, official inspections, quality controls in packing houses and/or establishment of pest-free areas might be needed to meet the phytosanitary requirements of these countries. The consequences would be minimal for citrus fruit intended for processing, as external lesions or spots on citrus fruit are not a quality issue for citrus for processing.

Control

Preventing the introduction into new areas

Since eradication and containment are difficult, phytosanitary measures should focus on preventing the introduction of the disease into new areas. Fruit is not considered to be a likely pathway for spread of *P. citricarpa* to new areas (USDA APHIS, 2010). Trees from certified *P. citricarpa*-free nurseries should be used for the establishment of new orchards, (Whiteside, 1965; Kiely, 1948b; Kotzé, 1981; Marchionatto, 1926; McOnie, 1964b; Silva-Junior *et al.*, 2016a;). It is also important to prevent the movement of leaf litter from infected orchards through vehicle/ machine movement (Dewdney *et al.*, 2018; Silva-Junior *et al.*, 2016a).

Cultural measures

In areas where *P. citricarpa* is present, sanitation practices in the orchard are the most important cultural management practices for *P. citricarpa* inoculum reduction. These include the removal and destruction of leaf litter from the orchard floor as fallen leaves may harbour spores (Scaloppi *et al.*, 2012; Spósito *et al.*, 2011; Truter, 2010, Bellotte *et al.*, 2013; Schutte and Kotzé, 1997). Removal of late-hanging fruit may prevent *P. citricarpa* infection of new fruit flushes, especially in citrus varieties where new and old fruit flushes can overlap (Calavan, 1960; Kiely, 1969; Kotzé, 1996; Dewdney *et al.*, 2018).

Maintaining tree vigour during fruit growth, using timely fertilization and irrigation regimes, may reduce *P. citricarpa* incidence (Calavan, 1960; Dewdney *et al.*, 2018; Kotzé, 1981). Declining trees are more susceptible and thus management practices for pest and disease control should be used.

Pruning of dead twigs remove *P. citricarpa* inoculum (Silva *et al.*, 2017; Silva-Junior *et al.*, 2016a) while pruning the tree canopy increases airflow which helps reduce leaf wetness periods, disease incidence and pycnidiospore dissemination (Calavan, 1960; Kotzé, 1981; Dewdney *et al.*, 2013).

Mulching with plants that grow between rows of orchards to cover leaf litter reduced disease incidence (Bellotte *et al.*, 2013; Schutte and Kotzé, 1997).

Host-plant resistance

Attempts have been made to produce tolerant hybrids using sour orange (*C. aurantium*) as a source of resistance (Anon., 1974). Rodriguez *et al.* (2018) produced transgenic sweet orange trees with reduced production of d-limonene in the fruit flavedo and enhanced resistance against *P. citricarpa*, but these materials need to be assessed under field conditions. According to Miles *et al.* (2019) hybrid progeny from crosses using pomelo as a parent is preliminary evidence of segregation for citrus black spot immunity. These preliminary results could open new perspectives for breeding *P. citricarpa* -resistant citrus cultivars.

Chemical control

Effective chemical control relies heavily on well-timed applications of protectant and systemic fungicides (Kellerman and Kotzé, 1979; Lanza *et al.*, 2018; Makowski *et al.*, 2014; Schutte *et al.*, 2003) integrated with cultural practices. Spore trapping, as well as rainfall and dew measurements have been helpful in determining the timing of ascospore release and the need for fungicide applications in South Africa (Kotzé, 2000). In Brazil, infections seem to occur to varying degrees throughout the susceptible period and fruit must be protected from petal fall to mid-summer (Reis, 2002). Disease management decisions should rely on seasonal dynamics studies of the *P. citricarpa* in environmental samples such as leaf litter. Hu *et al.* (2014) developed a real-time PCR test for this purpose.

For many years, protective products such as copper and dithiocarbamates were the basis for the control program (Bertus, 1981; Kiely, 1950, 1976; Kotzé, 1981; Tsai, 1981). Subsequently, mid-summer post-infectious applications of benzimidazoles were sufficient to control *P. citricarpa* in many areas (Kellerman and Kotzé, 1973, 1979). With the development of resistance (Herbert and Grech, 1985) many growers have returned to the use of protectant sprays or combinations of systemic and protectant products (Kotzé, 2000; Goes *et al.*, 2000; Goes, 2002). Use of strobilurins may reduce citrus black spot symptoms by almost 100%, (Dewdney *et al.*, 2018; Fogliata *et al.*, 2011; Miles *et al.*, 2004; Schutte *et al.*, 2003; Silva-Junior *et al.*, 2016a). However, there is a potential problem with strobilurins resistance (Hincapie *et al.*, 2014; Stammer *et al.*, 2013). Rotations of strobilurin fungicides with copper-based fungicides or mancozeb are recommended for effective *P. citricarpa* control (Schutte *et al.*, 2003; Miles *et al.*, 2004).

Postharvest

Fruit from citrus black spot-infected groves often bear quiescent infections that may later develop into black spot lesions in transport or at the final destination (Hall, 1973).

After harvest, hot water treatments or application of water-wax emulsions have been shown to reduce the development of citrus black spot during storage (Korf *et al.*, 2001; Seberry *et al.*, 1967; Wild, 1981). Storage in the dark and at low temperatures tends to reduce the development of disease symptoms (Kiely, 1970; Korf *et al.*, 2001; Agostini *et al.*, 2006; Brodrick and Rabie, 1970). On the other hand, if it is desirable that black spot symptoms are

expressed as soon as possible for detection of the disease, then fruit should be held at 27°C under continuous light. In Brazil, Uruguay and South Africa, ethephon has been used to induce symptom expression in citrus fruits intended for export (Baldassari *et al.*, 2007)

Schreuder *et al.* (2018) demonstrated that the combination of standard packhouse treatments (including pre-packhouse drench with guazatine or propiconazole in combination with pyrimethanil, thiabendazole and 2,4-D; chlorine wash; dip treatment in imazalil; and brush application of a wax coating incorporated with imazalil, thiabendazole and 2,4-D) consistently showed moderate to high levels of control of *P. citricarpa* in lemons and oranges while cold storage subsequent to packhouse treatments (as is common shipping protocol) further improved the levels of control. According to Yan *et al.* (2016), postharvest fungicide applications could reduce *P. citricarpa* severity, but not incidence, on orange fruit that are still asymptomatic at harvest. Agostini *et al.* (2006) also reported no significant control with postharvest fungicide treatments and suggested that the most effective means to reduce postharvest development of symptoms is through preventive application of fungicides during the fruit growing season and cold storage of harvested fruit.

Phytosanitary risk

Though of tropical origin, the fungus has established itself and causes serious damage in subtropical climates, e.g. China, New South Wales (Australia) and South Africa. The detection of *P. citricarpa* in 2019 in citrus orchards in Tunisia confirms that the pathogen has the potential to enter and possibly establish in the EPPO region. The origin of this outbreak is unknown, but it is suspected that infected plant material had been brought illegally (import of citrus plants for planting is prohibited in Tunisia) and that the floods which occurred in 2018 in the infected area facilitated fungal dispersal (EPPO, 2019). Although, there are some uncertainties about the potential of establishment of *P. citricarpa* in citrus-growing countries (EFSA, 2014), it is recognized that this pathogen has the potential to cause direct and indirect losses (i.e. reduced market access) to citrus production in the EPPO region.

PHYTOSANITARY MEASURES

In citrus-producing countries of the EPPO region, it is usually prohibited to import citrus plants for planting from outside the region. This measure effectively covers the risk of introducing *P. citricarpa* (and other citrus pests) via imports of planting material. In some cases (e.g. valuable breeding material), certification and pre- and post-entry quarantine systems can be envisaged. *P. citricarpa* can readily be carried on imported citrus fruits, but the risk of spread from these is considered to be relatively low. However, fruits from infested countries should come from orchards found free from, or be treated against the pathogen. The induction of precocious symptoms expression can be applied at the point of entry to help detecting latent infections. As explained above, in countries where *P. citricarpa* is present, exporters are performing an ethephon treatment to enhance symptom expression on exported fruits. The application of strict waste processing measures would probably be effective in reducing the transfer of *P. citricarpa* from infected citrus fruit to citrus orchards, but this would probably be difficult to apply in practice. After establishment, *P. citricarpa* has not been eradicated anywhere and is reported to be very difficult to contain. Therefore, risk reduction options to prevent the entry of the pathogen have been evaluated as being the most effective (EFSA, 2014).

REFERENCES

- Agostini JP, Peres NA, Mackenzie SJ, Adaskaveg JE & Timmer LW (2006) Effect of fungicides and storage conditions on postharvest development of citrus black spot and survival of *Guignardia citricarpa* in fruit tissues. *Plant Disease* **90**, 1419-1424.
- Aguiar RL, Scaloppi EMT, de Goes A & Spósito MB (2012) [Incubation period of *Guignardia citricarpa* at the different phenological stages in sweet orange 'Valencia']. *Tropical Plant Pathology* **37**, 155-158 (in Portuguese).
- Aguilar-Vildoso C, Baldini J, Feichtenberger E, de Goes A & Spósito M (2002) [Technical Manual with Procedures for Citrus Black Spot]. Brasília, Ministério da Agricultura, Pecuária e Abastecimento, Departamento de Defesa e Inspeção Vegetal. *Projeto CEMERCOSUL ALA 93/143*. 59 pp. (in Portuguese).

- Aguilar-Vildoso C, Baldini J, Feichtenberger E, de Goes A & Spósito M (2002) [Technical Manual with Procedures for Citrus Black Spot]. Brasília, Ministério da Agricultura, Pecuária e Abastecimento, Departamento de Defesa e Inspeção Vegetal. *Projeto CEMERCOSUL ALA 93/143*. 59 pp. (in Portuguese).
- Allen DJ (1971) Some newly recorded diseases of minor horticultural crops in Tanzania. *East African Agricultural and Forestry Journal* **37**, 22-25.
- Amorim R, Daiani CS, Ferreira-Maba L, Aluizio R, Goulin EH, Takita MA, Machado MA & Glienke C (2017) MAT gene idiomorphs suggest a heterothallic sexual cycle in the citrus pathogen *Phyllosticta citricarpa*. *European Journal of Plant Pathology* **147**, 325-337.
- Araújo D, Raetano CG, Ramos HH, Spósito MB, Prado EP (2013) Interference of spray volume reduction in citrus black spot (*Guignardia citricarpa* Kiely) control in 'Valencia' citrus fruits. *Summa Phytopathologica* **39**(3), 172-179 (in Portuguese).
- Baayen RP, Bonants PJM, Verkley G, Carroll GC, van der Aa HA, de Weerd M, van Brouwershaven IR, Schutte GC, Maccheroni WJr, de Blanco CG, Azevedo JL (2002) Nonpathogenic isolates of the citrus black spot fungus, *Guignardia citricarpa*, identified as a Baarcosmopolitan endophyte of woody plants, *G. mangiferae* (*Phyllosticta capitalensis*). *Phytopathology* **92**(5), 464-477.
- Baldassari RB, Reis RF & de Goes A (2006) Susceptibility of fruits of the Valencia and Natal sweet orange varieties to *Guignardia citricarpa* and the influence of the coexistence of healthy and symptomatic fruits. *Fitopatologia Brasileira* **31**, 337-341.
- Baldassari RB, Brandimarte I, Andrade AG, Goncalves de Souza DC, Moretto C & De Goes A (2007) [Induction of the precoce expression of *Guignardia citricarpa* symptoms in fruits of pera-rio sweet orange]. *Revista Brasileira de Fruticultura* **29**, 269-275 (in Portuguese).
- Baldassari RB, Wickert E & Goes A (2008) Pathogenicity, colony morphology and diversity of isolates of *Guignardia citricarpa* and *G. mangiferae* isolated from *Citrus* spp. *European Journal of Plant Pathology* **120**, 103-110.
- Bellotte JAM, Kupper KC, Rinaldo D, de Souza A & de Goes A (2013) The effects of inter-crop cultivation between rows of citrus crop on spreading of *Guignardia citricarpa* ascospores and in the citrus black spot occurrence. *Revista Brasileira de Fruticultura* **35**, 102-111.
- Benson AH (1895) Black spot of the orange. *Agricultural Gazette of New South Wales* **6**, p 249.
- Bertus AL (1981) Fungicidal control of black spot and melanose on coastal Valencia oranges in New South Wales. *Australasian Plant Pathology* **10**, 53-55.
- Bonants PJM, Carroll GC, de Weerd M, van Brouwershaven IR & Baayen RP (2003) Development and validation of a fast PCR-based detection method for pathogenic isolates of the Citrus Black Spot fungus, *Guignardia citricarpa*. *European Journal of Plant Pathology* **109**, 503-513.
- Brodrick HT & Rabie CJ (1970) Light and temperature effects on symptom development and sporulation of *Guignardia citricarpa* Kiely, on *Citrus sinensis* (Linn) Osbeck. *Phytophylactica* **2**, 157-163.
- Calavan EC (1960) Black spot of citrus. *Citrus Grower* **323**, 11-15.
- Carbone I & Kohn LM (1999) A method for designing primer sets for the speciation studies in filamentous ascomycetes. *Mycologia* **91**, 553-556.
- Carstens E, Le Roux H, Holtzhausen M, Van Rooyen L, Coetzee J, Wentzel R, Laubscher W, Dawood Z, Venter E, Schutte G, Fourie P & Hattingh V (2012) Citrus black spot is absent in the Western Cape, Northern Cape and Free State Provinces. *South African Journal of Science* **108**, 6 pp.

- Carstens E, Linde CC, Slabbert R, Miles AK, Donovan NJ, Li H, Zhang K, Dewdney MM, Rollins JA, Glienke C, Schutte GC, Fourie PH, and McLeod A (2017) A Global Perspective on the Population Structure and Reproductive System of *Phyllosticta citricarpa*. *Phytopathology* **107**, 758-768.
- Chiu RJ (1955) Studies on black spot of citrus. *Journal of Agriculture and Forestry* **9**, 1-8.
- Cobb NA (1897) Letters on the diseases of plants: black-spot of the orange. *Agr. Gazette New South Wales* **8**, 229-231.
- De Hoog GS & Gerrits van den Ende AHG (1998) Molecular diagnostics of clinical strains of filamentous basidiomycetes. *Mycoses* **41**, 183-189.
- Dewdney MM, Schubert TS, Estes MR, Roberts PD & Peres NA (2018) Citrus black spot. In: Diepenbrock LM, Dewdney MM, Vashisth T (eds) *Florida Citrus Production Guide*. Gainesville: University of Florida, Institute of Food and Agricultural Services, pp 129-134.
- Dummel DM, Agostini JP & Moschini R (2015) Predictive model for ascospore release of *Guignardia citricarpa* using climatological data. *Proceedings of the XIIth International Citrus Congress*, Valencia, Spain,
- Everett KR, Rees-George J (2006) Reclassification of an isolate of *Guignardia citricarpa* from New Zealand as *Guignardia mangiferae* by sequence analysis. *Plant Pathology* **55**(2), 194-199.
- EFSA (2014) Scientific Opinion on the risk of *Phyllosticta citricarpa* (*Guignardia citricarpa*) for the EU territory with identification and evaluation of risk reduction options. *EFSA Journal* **12**(2), 3557, 243 pp. <https://doi.org/10.2903/j.efsa.2014.3557>
- EPPO (2019) First report of *Phyllosticta citricarpa* in Tunisia. *EPPO Reporting Service* no. 07 - Num. article: 2019/141.
- EPPO (2020) EPPO Standard PM 7/17. Diagnostic protocols for regulated pests: *Phyllosticta citricarpa* (formerly *Guignardia citricarpa*). *EPPO Bulletin* **50**(3), 440-461. <https://doi.org/10.1111/epp.12700>
- FAO (1960) *Quarterly Report July to September 1960*. *FAO Plant Protection Committee for the South East Asia and Pacific Region*, pp. 1-2. FAO, Bangkok, Thailand.
- FAO (2016) ISPM 27. Diagnostic protocols for regulated pests DP 5: *Phyllosticta citricarpa* (McAlpine) Aa on fruit. *International Plant Protection Convention (IPPC)*, FAO, Rome.
- Fogliata GM, Muñoz ML, Rojas AA & Ploper D (2011) [Efficiency of three strobilurins to control reddish spot (*Guignardia mangiferae*) and black spot (*Guignardia citricarpa*) in lemon fruits in Tucumán, Argentina]. *Revista Industrial y Agrícola de Tucumán* **88**, 37-45 (in Spanish).
- Fourie P, Schutte T, Serfontein S & Swart F (2013) Modelling the effect of temperature and wetness on *Guignardia pseudothecium* maturation and ascospore release in citrus orchards. *Phytopathology* **103**, 281-292.
- FUNDECITRUS (2005) [Black Spot Handbook]. Brazil, Araraquara: *Fundo Paulista de Defesa da Citricultura*. 10 pp. (Boletim Técnico) (in Portuguese)
- Frare GF, Silva-Junior GJ, Bassanezi RB, Ramires TG & Amorim L (2019) Sweet orange fruit age and inoculum concentration affect expression of citrus black spot symptoms. *Plant Disease* **103**(5), 913-921.
- Gent-Pelzer MPE van., van Brouwershaven IR, Kox LFF & Bonants PJM (2007) A TaqMan PCR method for routine diagnosis of the quarantine fungus *Guignardia citricarpa* on citrus fruit. *Journal of Phytopathology* **155**, 357-363.
- Glienke C, Pereira OL, Stringari D, Fabris J, Kava-Cordeiro V, Galli-Terasawa L, Cunningham J, Shivas RG, Groenewald JZ & Crous PW (2011) Endophytic and pathogenic *Phyllosticta* species, with reference to those associated with Citrus Black Spot. *Persoonia Molecular Phylogeny and Evolution of Fungi* **26**, p 47.

- Goes A de (2002) [Effect of systemic and protective fungicides on black spot control of citrus fruits caused by *Guignardia citricarpa*]. *Summa Phytopathologica* **28**, 9-13 (in Portuguese).
- Goes A de, Andrade AG & Moretto KCK (2000) [Effect of different types of oils on benomyl + mancozeb mixture in the control of *Guignardia citricarpa*, causal agent of citrus fruits black spot]. *Summa Phytopathologica* **26**, 233-236 (in Portuguese).
- Guarnaccia V, Gehrman T, Silva-Junior GJ, Fourie PH, Haridas S, Vu D, Spatafora J, Martin FM, Robert V, Grigoriev IV, Groenewald JZ, Crous PW (2019) *Phyllosticta citricarpa* and sister species of global importance to *Citrus*. *Molecular Plant Pathology* **20**(2), 1649-1635.
- Guarnaccia V, Groenewald JZ, Li H, Glienke C, Carstens E, Hattingh V, Fourie PH & Crous PW (2017) First report of *Phyllosticta citricarpa* and description of two new species, *P. paracapitalensis* and *P. paracitricarpa*, from citrus in Europe. *Studies in Mycology* **87**, 161-185.
- Guerber JC, Liu B, Correll JC & Johnston PR. (2003) Characterization of diversity in *Colletotrichum acutatum* sensu lato by sequence analysis of two gene introns, mtDNA and intron RFLPs, and mating compatibility. *Mycologia* **95**, 872-895.
- Hall EG (1973) Storage and market diseases of [citrus] fruit. XVI. *CSIRO Food Research Quarterly* **33** (suppl.), p 3.
- Hendricks KE, Christman MC & Roberts PD (2017) Spatial and temporal patterns of commercial citrus trees affected by *Phyllosticta citricarpa* in Florida. *Scientific Reports* **7**, p 1641.
- Herbert JA & Grech NM (1985) A strain of *Guignardia citricarpa*, the citrus black spot pathogen, resistant to benomyl in South Africa. *Plant Disease*, **69**, 1007.
- Hincapie M, Wang NY, Peres NA & Dewdney MM (2014) Baseline sensitivity of *Guignardia citricarpa* isolates from Florida to azoxystrobin and pyraclostrobin. *Plant Disease* **98**, 780-789.
- Hu J, Johnson EG, Wang NYi, Davoglio T, and Dewdney MM. (2014) qPCR Quantification of Pathogenic *Guignardia citricarpa* and Nonpathogenic *G. mangiferae* in Citrus. *Plant Disease* **98**(1), 112-120.
- Hudson HJ (1962) Succession of micro-fungi on ageing leaves of *Saccharum officinarum*. *Transactions of the British Mycological Society* **45**, 395-423.
- Kellerman CR & Kotzé JM (1973) A single application of benomyl controls citrus black spot. *Citrus and Sub-tropical Fruit Journal* No. 476, pp. 19, 20, 22.
- Kellerman CR & Kotzé JM (1979) The black spot disease of citrus and its control in South Africa. *Proceedings of the International Society of Citriculture* **3**, 992-996.
- Kiely TB (1948) *Guignardia citricarpa* n.sp. and its relationship to the black spot disease of citrus in coastal orchards of New South Wales. *Journal of the Australian Institute of Agricultural Science* **14**, 81-83.
- Kiely TB (1949a) Preliminary studies on *Guignardia citricarpa* n.sp.: the ascigenous stage of *Phoma citricarpa* McAlp. and its relation to black spot of citrus. *Proceedings of the Linnean Society of New South Wales* **73**, 249-292.
- Kiely TB (1949b) Black spot of citrus in New South Wales coastal orchards. *Agricultural Gazette of New South Wales* **60**, 17-20.
- Kiely TB (1950) Control and epiphytology of black spot of citrus on the central coast of New South Wales. *Science Bulletin New South Wales Department of Agriculture* No. 71, 1-88.
- Kiely TB (1960) Speckled blotch of citrus. *Agricultural Gazette of New South Wales* **71**, 474-476.
- Kiely TB (1970) Black Spot of Citrus. *The Fruit and World Market Grower* February, 57- 60.

- Kiely TB (1969) Black spot of citrus. *Agricultural Gazette of New South Wales* **80**, 658-662.
- Kiely TB (1976) Control measures for black spot of Valencias. *Rural Newsletter* **59**, 35-36.
- Korf HJG, Schutte GC & Kotzé JM (2001) Effect of packhouse procedures on the viability of *Phyllosticta citricarpa*, anamorph of the citrus black spot pathogen. *African Plant Protection* **7**, 103-109.
- Kotzé JM (1963) Studies on the black spot disease of citrus caused by *Guignardia citricarpa* Kiely, with particular reference to its epiphytology and control in Letaba. *D.Sc. (Agric.) thesis*. University of Pretoria, South Africa.
- Kotzé JM (1981) Epidemiology and control of citrus black spot in South Africa. *Plant Disease Reporter* **65**, 945-950.
- Kotzé JM (2000) Black spot. In: Timmer LW, Garnsey SM & Graham JH (eds.) *Compendium of Citrus Diseases*, 2nd edn, APS Press, Saint Paul, MN (US), pp. 23-25.
- Lanza FEE, Metzker TG, Vinhas T, Behlau F & Silva GJJ (2018) Critical fungicide spray period for Citrus Black Spot control in São Paulo State. Brazil. *Plant Disease* **102**, 334-340.
- Lee YS (1969) [Pathogenicity of different isolates of *Guignardia citricarpa* Kiely from various sources to Ponkan fruits]. *Journal of Taiwan Agricultural Research* **18**, 45-50 (in Chinese).
- Lee YS & Huang CS (1973) Effect of climatic factors on the development and discharge of ascospores of the citrus black spot fungus]. *Journal of Taiwan Agricultural Research* **22**, 135-144.
- Liu YJ, Whelen S & Hall BD (1999) Phylogenetic relationships among ascomycetes: evidence from an RNA polymerase II subunit. *Molecular Biology and Evolution* **16**, 1799-1808.
- Magarey RD, Hong SC, Fourie PH, Christie DN, Miles AK, Schutte GC & Gottwald TR (2015) Prediction of *Phyllosticta citricarpa* using an hourly infection model and validation with prevalence data from South Africa and Australia. *Crop Protection* **75**, 104-114.
- Makowski D, Vicent A, Pautasso M, Stancanelli G & Rafoss T (2014) Comparison of statistical models in a meta-analysis of fungicide treatments for the control of citrus black spot caused by *Phyllosticta citricarpa*. *European Journal of Plant Pathology* **139**, 79-94.
- Marchionatto JB (1926) Fitoparasitos de la Argentina nuevos o poco conocidos in *Physis*. T. VIII, 367-372 (in Spanish).
- Marques JPR, Spósito MB, Mello AFS, Amorim L, Mondin M, Appezzato-da-Gloria B (2012) Histopathology of black spot symptoms in sweet oranges. *European Journal of Plant Pathology* **133**, 439-448.
- Martínez-Minaya J, Conesa D, López-Quílez A & Vicent A (2018) Spatial and climatic factors associated with the geographical distribution of citrus black spot disease in South Africa. A Bayesian latent Gaussian model approach. *European Journal of Plant Pathology* **151**, 991-1007.
- McAlpine D (1899) The fungus diseases of citrus trees in Australia, and their treatment. *Government Printer*, Melbourne, Australia.
- McMillan RT (1986) *Guignardia citricarpa* a cause of black spot on mango in Florida. *Journal of Phytopathology* **117**, 260-264.
- McOnie KC (1964a) The latent occurrence in citrus and other hosts of a *Guignardia* easily confused with *G. citricarpa*, the citrus black spot pathogen. *Phytopathology* **54**, 40-43.
- McOnie KC (1964b) Source inoculum of *Guignardia citricarpa*, the citrus black spot pathogen. *Phytopathology* **54**, 64-67.

- McOnie KC (1964c) Apparent absence of *Guignardia citricarpa* Kiely from localities where citrus black spot is absent. *South African Journal of Agricultural Science* **7**, 347-354.
- McOnie KC (1964d) Orchard development and discharge of ascospores of *Guignardia citricarpa* and the onset of infection in relation to the control of citrus black spot. *Phytopathology* **54**, 1448-1453.
- McOnie KC (1964e) Speckled blotch of citrus induced by the citrus black spot pathogen, *Guignardia citricarpa*. *Phytopathology* **54**, 1488-1489.
- McOnie KC (1967) Germination and infection of citrus by ascospores of *Guignardia citricarpa*. *Phytopathology* **57**, 743-746.
- Meyer L, Slippers B, Korsten L, Kotz T JM & Wingfield MJ (2001) Two distinct *Guignardia* species associated with citrus in South Africa. *South African Journal of Science* **97**(5/6), 191-194.
- Miles AK, Willingham SL & Cooke AW (2004) Field evaluation of strobilurins and a plant activator for the control of citrus black spot. *Australasian Plant Pathology* **33**, 371-378.
- Miles AK, Tan YP, Tan MK, Donovan NJ, Ghalayini A & Drenth A (2013) *Phyllosticta* spp. on cultivated citrus in Australia. *Australasian Plant Pathology* **42**, 461-467.
- Miles AK, Smith MW, Tran NT, Shuey TA, Dewdney MM & Drenth A (2019) Identification of resistance to Citrus Black Spot using a novel in-field inoculation assay. *Hortscience* **54**(10), 1673-1681.
- Moncalvo JM, Wang HH & Hseu RS (1995) Phylogenetic relationships in *Ganoderma* inferred from the internal transcribed spacer and 25S ribosomal DNA sequences. *Mycologia* **87**, 223-238.
- Myllys L, Stenroos S & Thell A (2002) New genes for phylogenetic studies of lichenized fungi: glyceraldehyde-3-phosphate dehydrogenase and betatubulin genes. *Lichenologist* **34**, 237-246.
- NAPPO (2010) Phytosanitary Alert System: Confirmation of citrus black spot (*Guignardia citricarpa*) in Florida - United States. NAPPO. <http://www.pestalert.org/oprDetail.cfm?oprID=421>
- Noronha MA (2002) [Diagrammatic scale for evaluation of black spot on citrus leaves and effect of temperature and wetting duration on pre-penetration of *Guignardia citricarpa* Kiely conidia [*Phyllosticta citricarpa* (McAlp.) van der Aa]. PhD Thesis, Universidade de Sao Paulo, Sao Paulo, Brazil, 67 pp. (in Portuguese).
- Norvell LL (2011) Fungal nomenclature. 1. Melbourne approves a new code. *Mycotaxon* **116**, 481-490.
- O'Donnell K, Kistler HC, Cigelnik E, Ploetz RC (1998) Multiple evolutionary origins of the fungus causing Panama disease of banana: concordant evidence from nuclear and mitochondrial gene genealogies. *Proceedings of the National Academy of Sciences of the United States of America* **95**, 2044-2049.
- Paul I, van Jaarsveld AS, Korsten L & Hattingh V (2005) The potential global geographical distribution of citrus black spot caused by *Guignardia citricarpa* (Kiely): likelihood of disease establishment in the European Union. *Crop Protection* **24**, 297-308.
- Perryman SAM & West JS (2014) Splash dispersal of *Phyllosticta citricarpa* pycnidiospores from infected citrus. *EFSA supporting publication* 2014-EN-560, 30 pp.
- Perryman SAM, Clark SJ & West JS (2014) Splash dispersal of *Phyllosticta citricarpa* conidia from infected citrus fruit. *Scientific Reports* **4**, 6568.
- Reis RR (2002) Influence of climate control factors on the production and release of *Guignardia citricarpa* ascospores in 'Natal' and 'Valencia' orange orchards]. *Jaboticabal*: [s.n.]. vi, 87 f. Dissertação (mestrado) - Universidade Estadual Paulista, Faculdade de Ciências Agrárias e Veterinárias (in Portuguese).

- Reis RF, Timmer LW & de Goes A (2006) Effect of temperature, leaf wetness and rainfall on the production of *Guignardia citricarpa* ascospores and on black spot severity on sweet orange. *Fitopatologia Brasileira* **31**, 29-34.
- Reis RF, de Goes A & Pereira GT (2003) [Effect of copper oxychloride application on different times for the control of citrus black spot caused by *Guignardia citricarpa*]. *Summa Phytopathologica* **29**, 12-18 (in Portuguese).
- Robbs CF & Bittencourt AM (1995) [Fruit black spot is one of the limiting factors for citrus yield in the state of Rio de Janeiro]. *Comunicado Técnico, EMBRAPA, CTAAA*, 19, 1-5 (in Portuguese).
- Rodriguez A, Kava V, Latorre-Garcia L, da Silva GJJ, Pereira RG, Glienke C, Ferreira-Maba LS, Vicent A, Shimada T & Pena L (2018) Engineering D-limonene synthase down-regulation in orange fruit induces resistance against the fungus *Phyllosticta citricarpa* through enhanced accumulation of monoterpene alcohols and activation of defence. *Molecular Plant Pathology* **19**, 2077-2093.
- Roy AK (1965) Additions to the fungus flora of Assam - I. *Indian Phytopathology* **18**, 327-334.
- Sanders GM, Meyer L & Kosten L (2003) Application of species-specific primers in the South African citrus industry. *Proceedings of the International Congress Plant Pathology*, Christchurch, New Zealand, 82 pp.
- Scaloppi EMT, Aguiar RL, de Goes A & Sposito MB (2012) [Effect of cultural and chemical management in the incidence and severity of citrus black spot.] *Revista Brasileira de Fruticultura* **34**, 102-108 (in Portuguese).
- Schreuder W, du Plooy W, Erasmus A, Savage C, Basson E, Lennox C & Fourie PH (2018) Postharvest fungicide treatments and cold storage control citrus black spot infections. *Crop Protection* **112**, 332-342.
- Schirmacher AM, Tomlinson JA, Barnes AV, Barton VC (2019) Species-specific real-time PCR for diagnosis of *Phyllosticta citricarpa* on *Citrus* species. *EPPO Bulletin* **49**, 306-313.
- Schubert TS, Dewdney MM, Peres NA, Palm ME, Jeyaprakash A, Sutton B, Mondal SN, Wang NY, Rascoe J & Picton DD (2012) First report of *Guignardia citricarpa* associated with citrus black spot on sweet orange (*Citrus sinensis*) in North America. *Plant Disease* **96**(8), 1225.
- Schutte GC, Mansfield RI, Smith H & Beeton KV (2003) Application of azoxystrobin for control of benomyl-resistant *Guignardia citricarpa* on 'Valencia' oranges in South Africa. *Plant Disease* **87**, 784-788.
- Schutte GC & Kotzé JM (1997) Grass mulching as part in integrated control programme for the control of citrus black spot. *Citrus Journal* **7**, 18-20.
- Schutte GC, Kotzé C & Korf HJG (2014) Influence of sunlight exposure on fertility of *Phyllosticta citricarpa* pycnidia in citrus black spot lesions on grapefruit and Valencia orange rinds. *SA Fruit Journal*, April, 54-57.
- Silva AD, Savi DC, Raiser PHS, Gonçalves FP, Kava V, Galli-Terasawa LV & Glienke C (2017) Epidemiological aspects of *Phyllosticta citricarpa* colonization and viability in *Citrus sinensis*. *Journal of Plant Diseases and Protection* **124**, 73-80.
- Silva-Junior GJ, Feichtenberger E, Sposito MB, Amorim L, Bassanezi RB & Goes A (2016a) Pinta preta dos citros: a doença e seu manejo. v. 1. Araraquara, São Paulo, Brazil: *Fundecitrus*, 208 pp. (in Portuguese).
- Snowdon AL (1990) Black spot. In: Snowdon AL (ed) *A colour atlas of post-harvest diseases and disorders of fruits and vegetables, Vol. I. General Introduction and fruits*. Wolfe Scientific Ltd. London, UK, pp. 62-63.
- Sousa PFC & de Goes A (2010) [Reaction of sweet orange against resistance to *Guignardia citricarpa*]. *Revista Brasileira de Fruticultura* **32**, 718-725. (in Portuguese)
- Sposito MB, Bassanezi RB & Amorim L (2004) Resistance to citrus black spot by the analyses of disease progress curves. *Fitopatologia Brasileira* **29**, 532-537.

- Spósito MB, Amorim L, Bassanezi RB, Bergamin Filho A & Hau B (2008) Spatial pattern of black spot incidence within citrus trees related to disease severity and pathogen dispersal. *Plant Pathology* **57**, 103-108.
- Spósito MB, Amorim L, Bassanezi RB, Yamamoto PT, Felipe MR & Czermaini ABC (2011) Relative importance of inoculum sources of *Guignardia citricarpa* on the citrus black spot epidemic in Brazil. *Crop Protection* **30**, 1546-1552.
- Stammler G, Schutte GC, Speakman J, Miessner S & Crous PW (2013) *Phyllosticta* species on citrus: risk estimation of resistance to QoI fungicides and identification of species with cytochrome b gene sequences. *Crop Protection* **48**, 6-12.
- Stringari D, Glienke C, Christo Dde, Maccheroni Júnior W & de Azevedo JL (2009) High molecular diversity of the fungus *Guignardia citricarpa* and *Guignardia mangiferae* and new primers for the diagnosis of the Citrus Black Spot. *Brazilian Archives of Biology and Technology* **52**(5), 1063-1073.
- Sung GH, Sung JM, Hywel-Jones NL & Spatafora JW (2007) A multi-gene phylogeny of *Clavicipitaceae* (Ascomycota, Fungi): identification of localized incongruence using a combinational bootstrap approach. *Molecular Phylogenetics and Evolution* **44**, 1204-1223.
- Sutton BC & Waterston JM (1966) *Guignardia citricarpa*. *CMI Descriptions of Pathogenic Fungi and Bacteria* No. 85. CAB International, Wallingford, UK.
- Timmer LW (1999) Diseases of fruit and foliage. In: Timmer LW & Duncan LW (eds) *Citrus health management*. American Phytopathological Society, St. Paul, MN, USA, pp 107-115.
- Tomlinson JA, Ostojca-Starzewska S, Webb K, Cole J, Barnes A, Dickinson M, Boonham N (2013) A loop-mediated isothermal amplification-based method for confirmation of *Guignardia citricarpa* in citrus black spot lesions. *European Journal of Plant Pathology* **136**, 217-224.
- Tran NT, Miles AK, Dietzgen RG, Dewdney MM, Zhang K, Rollins JA & Drenth A (2017) Sexual reproduction in the citrus black spot pathogen, *Phyllosticta citricarpa*. *Phytopathology* **107**, 732-739.
- Truter M (2010) Epidemiology of Citrus Black Spot disease in South Africa and its impact on phytosanitary trade restrictions. PhD thesis. University of Pretoria, Pretoria, South Africa.
- Ullasa BA & Rawal RD (1984) *Guignardia* fruit rot of guava - a new disease from Bangalore. *Current Science* **53**, 435-436.
- USDA APHIS (United States Department of Agriculture Animal and Plant Health Inspection Service) (2010) Risk assessment of *Citrus* spp. fruit as a pathway for the introduction of *Guignardia citricarpa* Kiely, the organism that causes Citrus Black Spot disease. *Center for Plant Health Science and Technology, Plant Epidemiology and Risk Analysis Laboratory*, Raleigh, NC, USA.
- Van der Aa HA (1973) Studies in *Phyllosticta* I. *Studies in Mycology* No. 5, 1-110.
- Vilgalys R & Hester M (1990) Rapid genetic identification and mapping of enzymatically amplified ribosomal DNA from several *Cryptococcus* species. *Journal of Bacteriology* **172**, 4238-4246.
- Wager VA (1952) The black spot disease of citrus in South Africa. *Science Bulletin, Department of Agriculture, Union of South Africa* No. 303, 1-52.
- Wang X, Chen G, Huang F, Zhang J, Hyde KD & Li H (2012) *Phyllosticta* species associated with citrus diseases in China. *Fungal Diversity* **52**, 209-224.
- Wang NY, Zhang K, Huguët-Tapia JC, Rollins JA & Dewdney MM (2016) Mating type and simple sequence repeat markers indicate a clonal population of *Phyllosticta citricarpa* in Florida. *Phytopathology* **106**, 1300-1310.

Wikee S, Lombard L, Crous PW, Nakashima C, Motohashi K, Chukeatirote E, Alias SA, McKenzie EHC & Hyde KD (2013) *Phyllosticta capitalensis*, a widespread endophyte of plants. *Fungal Diversity* **60**, 91-105.

White TJ, Bruns T, Lee S & Taylor J (1990) Amplification and direct sequencing of fungal ribosomal RNA genes for phylogenetics. In: Innis MA, Gelfand DH, Sninsky JJ, White TJ (eds) *PCR protocols: a guide to methods and applications*. Academic Press, San Diego, California, pp 315–322.

Whiteside JO (1965) Black spot disease in Rhodesia. *Rhodesian Agricultural Journal* **62**, 87-91.

Whiteside JO (1967) Sources of inoculum of the black spot fungus, *Guignardia citricarpa* in infected Rhodesian citrus orchards. *Rhodesia, Zambia, Malawi Journal of Agricultural Research* **5**, 171-177.

Wickert E, de Goes A, Lemos EGM, de Souza A, da Silveira EL, Pereira FD & Rinaldo D (2009) [Phylogenetic relationships and diversity of isolates of *Guignardia* spp. from different hosts in the regions ITS1–5,8S-ITS2]. *Revista Brasileira de Fruticultura* **31**, 360-380 (in Portuguese).

Wild BL (1981) The effects of waxing citrus fruit. *Rural Newsletter* **79**, 14-19

Wu GA, Terol J, Ibanez V, López-García, A., Pérez-Román, E., Borredá, C, Domingo C, Tadeo FR, Carbonell-Caballero J, Alonso R, Curk F, Du D, Ollitrault P, Roose ML, Dopazo J, Gmitter FG Jr, Rokhsar DS & Talon M (2018) Genomics of the origin and evolution of Citrus. *Nature* **554**, 311-316.

Wulandari NF, To-anun C, Hyde KD, Duong LM, de Gruyter J, Meffert JP, Groenewald JZ & Crous PW (2009) *Phyllosticta citriasiana* sp. nov., the cause of Citrus tan spot of *Citrus maxima* in Asia. *Fungal Diversity* **34**, 23-39.

Yan J, Dewdney MM, Roberts PD & Ritenour MA (2016) The effects of postharvest hot water and fungicide treatments on *Guignardia citricarpa* growth and the development of citrus black spot symptoms on ‘Valencia’ orange fruit. *HortScience* **51**, 1555-1560.

Yonow T, Hattingh V & de Villiers M (2013) CLIMEX modelling of the potential global distribution of the citrus black spot disease caused by *Guignardia citricarpa* and the risk posed to Europe. *Crop Protection* **44**, 18-28.

CABI and EFSA resources used when preparing this datasheet

CABI (2019) Invasive species Compendium. *Guignardia citricarpa*. CABI Wallingford (GB).
<https://www.cabi.org/isc/datasheet/26154>

CABI/EPPO (2012) *Phyllosticta citricarpa*. Distribution Maps of Plant Diseases no. 53 (edition 7). CABI, Wallingford (GB).

EFSA (2014) Scientific Opinion on the risk of *Phyllosticta citricarpa* (*Guignardia citricarpa*) for the EU territory with identification and evaluation of risk reduction options. *EFSA Journal* **12**(2), 3557, 243 pp.
<https://doi.org/10.2903/j.efsa.2014.3557>

ACKNOWLEDGEMENTS

This datasheet was extensively revised in 2020 by Eleni Kalogeropoulou (MSc), Laboratory of Mycology, Department of Phytopathology, Benaki Phytopathological Institute, Kifisia, Greece. Her valuable contribution is gratefully acknowledged.

How to cite this datasheet?

EPPO (2024) *Phyllosticta citricarpa*. EPPO datasheets on pests recommended for regulation. Available online.
<https://gd.eppo.int>

Datasheet history

This datasheet was first published in the CABI/EPPO (1997) Quarantine Pests for Europe (2nd edition). CABI, Wallingford (GB). It is now maintained in an electronic format in the EPPO Global Database. The sections on 'Identity', 'Hosts', and 'Geographical distribution' are automatically updated from the database. For other sections, the date of last revision is indicated on the right.

CABI/EPPO (1997) Quarantine Pests for Europe (2nd edition). CABI, Wallingford (GB).



Co-funded by the
European Union