Cotton, cowpea and sesame are alternative crops to cucurbits in soils naturally infested with *Monosporascus cannonballus*

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ABSTRACT

Monosporascus cannonballus is an important cucurbit root pathogen which has been reported in the main production areas of melon and watermelon in Brazil and worldwide and potentially capable to colonize roots of different species. Crop rotation is considered an effective management strategy to prevent this disease. The aim of this study was to evaluate the response of different crops, pumpkin, cotton, cowpea, sesame, watermelon, melon, corn, cucumber, sorghum and tomato, to the infection of this pathogen. Seedlings were transplanted into plastic containers with an inoculum concentration of 20 colony forming units (CFU) g^{-1} of *M. cannonballus*. Fifty days after transplanting the variables analyzed were the degree of disease severity on the root system and the frequency of reisolation. On cucurbits, the results

demonstrated different degrees of susceptibility among crops and cultivars, being melon and watermelon the most sensitive species. In contrast, *Cucurbita* cultivars were the most tolerant. Regarding non-cucurbit crops, maize, sorghum and tomato presented root discoloration and *M. cannonballus* was reisolated from roots. Cotton, cowpea and sesame cultivars were not affected by the pathogen, so they can be considered as alternative crops to be cultivated, or in rotation with cucurbits, in *M. cannonballus* infested soils.

KEYWORDS: Crop rotation, host range, Monosporascus root rot and vine decline, pathogenicity, soilborne pathogen.

1 INTRODUCTION

Monosporascus cannonballus Pollack & Uecker is an important cucurbit root pathogen causing the disease known as "Monosporascus root rot and vine decline (MRRVD)" (Martyn & Miller, 1996). This soilborne fungus has been reported in the main production areas of melon (*Cucumis melo* L.) and watermelon [*Citrullus lanatus* (Thunb.) Matsum & Nakai] cultivation in Brazil (Sales Júnior et al., 2004, 2010) and in other 21 countries worldwide (Al-Mawaali, Al-Sadi, Al-Said, & Deadman, 2013; Cohen, Pivonia, Crosby, & Martyn, 2012b; Yan, Zang, Huang, & Wang, 2016).

Root rot caused by *M. cannonballus* is part of a complex syndrome where this fungus can be isolated alone or in association with other soilborne pathogens, such as *Acrocalymma vagum* Crous & Trakunyingcharoen (Armengol, Vicent, Martínez-Culebras, Bruton, & García Jiménez, 2003; Farr, Miller, & Bruton, 1998), *Fusarium oxysporum* f. sp. *melonis* Snyder & Hansen, *Macrophomina phaseolina* (Tassi) Goid. (Cohen, Elkabetz, & Edelstein, 2016; Cohen, Omari, Porat, & Edelstein, 2012a), *Fusarium solani* f. sp. *cucurbitae* Snyder & Hansen, *Olpidium* spp. (Aleandri et al., 2017; Cara et al., 2008; Stanghellini & Misaghi, 2011;

Stanghellini, Mohammadi & Adaskaveg, 2014), *Pythium spinosum* Swada and *Rhizoctonia solani* Kühn (Al-Sadi et al., 2011), and *Plectosphaerella melonis* (Watan & Sato) Phillips, Carlucci & Raimondo (Armengol et al., 1998; Bruton, Davis, & Gordon, 1995). In Brazil, this syndrome is considered an important limiting factor for cucurbits cultivation (Bezerra et al., 2013).

Monosporascus cannonballus is a thermophilic fungus, which seems to be adapted to Arid and Semi-arid climates, surviving in the soil in the absence of suitable hosts for long periods in the form of ascospores (Medeiros, Silva, Oliveira, Ferreira, & Sales Júnior, 2008). The symptoms associated with root rot caused by *M. cannonballus* can be easily observed on melon plants close to harvest (Cohen, Pivonia, Crosby, & Martyn, 2012b), where severe vine decline is observed. This is due to the rotting of the root system, which can no longer supply the water needs of the plant, leading it frequently to its death. In addition, the affected root system shows the presence of black perithecia from which abundant ascospores are produced, being the main fungus reproduction structures (Louws, Rivarda, & Kubota, 2010).

Several studies have reported different management strategies to control MRRVD, such as the use of green fertilization (Sales Júnior, Senhor, Michereff, & Medeiros, 2017), application of fumigants (Stanghellini et al., 2003), destruction of postharvest plant residues (Radewald, Ferrin, & Stanghellini, 2004), chemical control (Pivonia, Gerstl, Maduel, Levita, & Cohen, 2010), application of essential oils (Fernandes et al., 2015; Awad, 2016), the use of plant-growth promoting bacteria (Antonelli, xxx) and antagonistic biocontrol agents (Zhang, 1999; Júnior, 2007; Aleandri 2015), and grafting on *Cucurbita* hybrid rootstocks (Al-Mawaali, Al-Sadi, Al-Said, & Deadman, 2016; Beltrán, Vicent, García-Jiménez, & Armengol, 2008; Edelstein et al., 2017). However, some of these techniques are not sufficient if applied alone, but can be effective when sustainable measures are integrated (Medeiros, Silva, Oliveira, Ferreira, & Sales Júnior, 2008). In this sense, the practice of alternative management techniques such as crop rotation needs to be elucidated.

Previous studies have demonstrated that, in addition to the Cucurbitaceae family, *M. cannonballus* has been reported on roots of *Iris* sp., *Trifolium pratense* L. (red clover), *Medicago sativa* L. (alfalfa) and *Sesamum indicum* L. (sesame) (Sivanesan, 1991), *Triticum* sp. and *Achyrantes aspera* L. (Hawksworth, & Ciccarone, 1978) and *Lepidium lasiocarpum* Nutt. (Stanghellini, Kim, & Rasmussen, 1996) in field samples. In addition, *M. cannonballus* was isolated from artificially inoculated roots of *Zea mays* L. (corn), *Sorghum bicolor* L. (Moench) (sorghum), *Beta vulgaris* L. (beet), *M. sativa*, *Triticum aestivum* L. (wheat) and *Phaseolus vulgaris* L. (bean) (Mertely, Martyn, Miller, & Bruton, 1993). Therefore, it is important to evaluate the response of different crop species to *M. cannonballus* in order to determine which of them could be used in a crop rotation management program for this disease in Brazil and also in other cucurbit growing areas severely affected by this pathogen. In this sense, this study aims to assess the severity reaction on the root system of different selected cucurbit and non-cucurbit crops after the inoculation with two isolates of *M. cannonballus*.

2 MATERIALS AND METHODS

2.1 *M. cannonballus* isolates and inoculum preparation

Two *M. cannonballus* isolates were used in this study: CMM 2390 and CMM 3646, obtained from melon and *Boerhavia diffusa* L., respectively, which were deposited in the culture collection Prof. Maria Menezes of the Universidade Federal Rural de Pernambuco - UFRPE: (Pernambuco, Brazil). Previous trials demonstrated that these isolates were pathogenic to melon (Rodrigues, 2013).

Fungal inoculum was produced following the methodology described by Armengol et al. (1998). Cultures were grown on potato-dextrose agar (PDA) at 26ºC prior to introduction to a sand-oat hull (*Avena sativa* L.) medium (0.5 L sand, 46 g ground oat hulls, 37.5 mL distilled water). The medium was mixed and transferred to 1 L flasks, autoclaved on 3 successive days, then inoculated with each fungal isolate. When the colonized material was about 5 cm in diameter, the flasks were shaken to distribute the fungus evenly throughout the mix and incubated at 25–30ºC for 21–28 days. Following incubation, colony-forming units (CFU) were quantified by serial dilution using 1% hydroxyethyl cellulose.

2.2 Pathogenicity tests

Pathogenicity tests were conducted in a greenhouse at Mossoró, State of Rio Grande do Norte (RN); coordinates (5º11'15"S and 37º20'39" W, 18 m altitude).

The cultures and cultivars used in this experiment were melon: 'Goldex' and 'SF-69'; watermelon: 'Crimson Sweet' and 'Sugar Baby'; *Cucumis sativus* L. (cucumber): 'Aodai' and 'Marketer'; *Cucurbita* sp. (pumpkin): 'Bahiana' and 'Moranga'; *Solanum lycopersicum* L. (tomato): 'Santa Clara' and 'Santa Cruz'; *Gossypium hirsutum* L. (cotton): 'BRS 286' and 'BRS 335'; sesame: 'Seda' and 'G4'; corn: 'BRS 205' and 'AG 7098'; sorghum: 'Ponta Negra' and 'Santa Elisa'; and *Vigna unguiculata* (L.) Waup. (cowpea): 'BRS Cauamé' and 'BRS Itaim'. The non-cucurbit crops were selected because of their frequent use in the cucurbit off season in the melon and watermelon producing region in the Brazilian states of RN and Ceará (CE).

Two separate experiments were carried out, one for each *M. cannonballus* isolate. The experimental design was completely randomized with 20 treatments and four replicates per experiment, being the experimental unit composed by a potted plant.

Seeds from each crop and cultivar were surface disinfected with sodium hypochlorite (2.5% active chlorine) for 1 min and then seeded in expanded polystyrene trays containing

128 cells and filled with sterile Tropstrato® substrate. The seedlings were transplanted 9 days after sowing into plastic containers with a capacity of 2 L, filled with a 1: 1: 1 sterile mixture of soil, Tropstrato® substrate and washed sand, previously autoclaved at 120ºC for 1 h.

In each of the replicates, before inoculation, an inoculum concentration of 20 colony forming units (CFU) g^{-1} of the respective *M. cannonballus* isolate was added to the soil (Sales Júnior, Vicent, Armengol, García-Jiménez, & Kobori, 2002). Subsequently, the containers were incubated in a greenhouse under controlled conditions of 30-35°C and relative humidity 70% ± 2.

2.3 Disease severity evaluation

Fifty days after transplanting, the entire plants were collected carefully and the roots washed with running water to remove adhered soil remains. Then, the degree of severity reaction on the root system was evaluated using the score scale from 0 to 4 described by Armengol et al. (1998), where 0 = healthy roots; 1 = mild discoloration, 2 = moderate discoloration with few lesions; 3 = severe discoloration with abundant lesions and 4 = totally deteriorated. Then, resistance classes were assigned to the results of severity obtained, being: 0-1.0 = highly resistant; 1.01-2.0 = resistant; 2.01-3.0 = susceptible and 3.01-4.0 = highly susceptible.

2.4 Frequency of reisolation

Fungal isolation was conducted after disease severity evaluation in PDA with the addition of 500 ppm of streptomycin sulphate (PDAS). In each plant, seven small root fragments were taken from affected areas, and then plated in one PDAS Petri dish. Plates were incubated at 27-29°C in darkness for a five days period.

The growth of *M. cannonballus* colonies was assessed, and the frequency of isolation per treatment was determined using the following formula: Frequency = (F x 100) / TF, being F the number of fragments from which *M. cannonballus* was obtained and TF the total fragments plated in culture medium.

2.5 Statistical analysis

Severity results were analyzed with to the non-parametric Kruskal-Wallis test at the probability level of 5% ($p < 0.05$) using the software Assistat, version 7.7 (Silva & Azevedo, 2016).

3 RESULTS

3.1 Disease severity

Inoculation with *M. cannonballus* isolate CMM 2390 caused significant statistical effect on root disease severity among the different cultivars ($\chi 2 = 68.38$; $p < 0.05$) (Table 1).

The cultivars tested were grouped in the four classes of severity reaction, 30% of which were considered highly susceptible: melon: 'Goldex' (mean disease severity 3.50) and 'SF-69' (3.25); watermelon: 'Sugar Baby' (3.50); cucumber: 'Marketer' (3.75) and 'Aodai' (4.00); and Pumpkin: 'Bahiana' (3.75). The same percentage (30%) was obtained for watermelon: 'Crimson Sweet' (3.00); pumpkin: 'Moranga' (2.50); corn: 'BRS 205' (2.50) and 'AG 7098' (2.75); and tomato: 'Santa Cruz' (3.00) and 'Santa Clara' (3.00), which were considered susceptible to inoculation with isolate CMM 2390. In total 60% of the cultivars tested were classified as susceptible and highly susceptible to isolate CMM 2390. The sorghum cultivars: 'BRS Ponta Negra' and 'BRS Santa Elisa' and the sesame cultivars: 'G4' and 'Seda' were considered resistant to isolate CMM 2390, with mean disease severity values of 1.75; 1.50; 1.50 and 1.50, respectively. The other cultivars tested, cowpea: 'BRS Cauamé' and 'BRS Itaim' and cotton: 'BRS 335' and 'BRS 286' were considered highly resistant, obtaining mean disease severity values of 0.00; 0.00; 1.00 and 1.00, respectively (Table 1).

Similar results were obtained when the same cultivars were inoculated with *M. cannonballus* isolate CMM 3646. In this case, statistical analysis also confirmed significant difference among the cultivars ($\chi 2 = 65.62$, $p < 0.05$) (Table 1).

Of the cultivars tested, 25% resulted highly susceptible, being: melon: 'Goldex' (3.25) and 'SF-69' (mean disease severity 3.25); watermelon: 'Crimson Sweet' (3.25); cucumber: 'Aodai' (3.75); and pumpkin: 'Bahiana' (3.50). The following cultivars: watermelon 'Sugar Baby' (3.00); cucumber: 'Aeketer' (2.75), pumpkin: 'Moranga' (2.50); corn: 'AG 7098' (2.50); and tomato: 'Santa Cruz' (3.00) and 'Santa Clara' (3.00) were considered susceptible to *M. cannonballus* isolate CMM 3646. In total, 55% of the cultivars tested were rated as susceptible and highly susceptible to this isolate. In contrast, 45% of the cultivars tested were considered resistant or highly resistant. Sorghum cultivars: 'BRS Ponta Negra' and 'BRS Santa Elisa'; corn: 'BRS 205'; sesame: 'G4'; and cotton: 'BRS 335' were resistant and showed disease severity values of 1.75; 1.50; 2.00; 1.25 and 1.50, respectively. The other cultivars tested resulted highly resistant: cowpea: 'BRS Cauamé' (0.00) and 'BRS Itaim' (0.00); sesame: 'Seda' (1.00); and cotton 'BRS 286' (1.00) (Table 1).

3.2 Reisolation frequency

Reisolation frequency of the *M. cannonballus* isolate CMM 2390 from the roots of the inoculated cultivars presented the highest values for cucurbit cultivars: watermelon: 'Crimsom Sweet' (85.7%) and 'Sugar Baby' (53.6%); melon: ‘Goldex’ (53.6%) e ‘SF-69’ (42.8%); cucumber: ‘Marketer’ (39.3%) and 'Aodai' (39.3%); pumpkin: 'Moranga' (39.3%). One exception was the pumpkin cultivar 'Bahiana', which presented a low reisolation percentage (10.7%).

In the group of non-cucurbit crops, cotton cultivars: 'BRS 335' (0.0%) and 'BRS 286' (3.57%); sesame: 'G4' (0.0%) and 'Seda' (3.57%); cowpea: 'BRS Cauamé' (0.0%) and 'BRS Itaim' (0.0%); and tomato: 'Santa Cruz' (3.57%) presented very low or null percentages of reisolation. In contrast, corn cultivars: 'AG 7098' (53.6%) and 'BRS 205' (42.8%); sorghum 'BRS Ponta Negra' (28.6%); and tomato: 'BRS Santa Elisa' (14.3%) and 'Santa Clara' (21.4%), showed variable colonization with this isolate of *M. cannonballus* (Table 2).

Results of reisolation frequency from plants inoculated with isolate CMM 3646 were similar to those obtained with isolate CMM 2390. The highest reisolation values were obtained for cucurbit cultivars watermelon: 'Crimsom Sweet' (53.6%) and 'Sugar Baby' (53.6%), melon: 'Goldex' (39.3%) and 'SF-69' (32.1%) and cucumber: 'Marketer' (42.9%) and 'Aodai' (42.9%). The exception were the pumpkin cultivars 'Bahiana' and Moranga, which presented the same low reisolation percentage (7.1%). It was not possible to reisolate the fungus from the non-cucurbit crops cowpea: 'BRS Cauamé' and 'BRS Itaim', sesame: 'G4' and 'Seda' and cotton: 'BRS 335' and 'BRS 286'. The reisolation percentage in sorghum: 'BRS Santa Elisa' (3.57%), was lower than 5% and, in contrast, it was possible to reisolate *M. cannonballus* from corn cultivars 'BRS 205' (28.6%) and 'AG 7098' (42.8%) and tomato: 'Santa Cruz' (7.14%) and 'Santa Clara' 10.7% (Table 2).

4 DISCUSSION

In this study, the Cucurbitaceae family showed the highest levels of root damage after inoculation with *M. cannonballus*, being melon and watermelon the most sensitive species. These results agree with previous research that already indicated melon and watermelon as the most susceptible crops to this pathogen, although the cultivars used here are different from those evaluated previously. In fact, pathogenicity studies conducted up to the present time with commercial hybrids of melon and watermelon have not yet found any resistance to *M.*

cannonballus (Armengol et al., 1998; Davis et al., 2008; Martyn & Miller, 1996; Mertely, Martyn, Miller, & Bruton, 1993; Sales Júnior, Vicent, Armengol, García-Jiménez, & Kobori, 2002; Wolff & Miller 1998). King, Davis, Zhang, & Crosby (2010) reported some melon cultivars belonging to the types Conomom, Inodorus, Cantaloupensis and Agrestis as resistant to *M. cannonballus*, but the fruits produced by them have no commercial value, presenting low or no quality for the market.

Regarding reisolation frequency of *M. cannonballus*, also melon and watermelon showed the highest values. In a similar work, Mertely, Martyn, Miller, & Bruton (1993) obtained a reisolation percentage of *M. cannonballus* over 70% for the cultivars 'Black Diamond' and 'Royal Sweet '(watermelon)', 'Magnum 45' and 'Honeydew Green Flesh' (melon) and 'Poinsette 76 '(cucumber).

In our study the *Cucurbita* cultivars 'Bahiana' and 'Moranga' resulted susceptible to both *M. cannonballus* isolates inoculated but, in contrast, the reisolation frequency was low. Mertely, Martyn, Miller, & Bruton (1993) demonstrated the tolerance of *Cucurbita* cultivars to *M. cannonballus*, because they presented relatively low values of isolation frequency, when compared with those obtained with cucumber, melon and watermelon cultivars included in their inoculation experiments. Although Alfaro-Fernández & García-Luis (2009) demonstrated with histological studies that *M. cannonballus* is capable to infect *C. maxima* tissues to some extent, subsequent studies have explored the good performance of *Cucurbita* hybrid rootstocks for the management of MRRVD in field conditions (Al-Mawaali, Al-Sadi, Al-Said, & Deadman, 2016; Beltrán, Vicent, García-Jiménez, & Armengol, 2008; Cohen, Burger, Horev, Porat, & Edelstein, 2005; Demartelaere, Freitas, Soares, Queiroz, & Sales Júnior, 2015; Edelstein, M., Cohen, R., Burger, Y., & Shriber, 1999; Kim et al., 2016; Louws, Rivarda, & Kubota, 2010; Park et al., 2013).

Regarding non-cucurbit crops, our results were similar to that reported by Mertely, Martyn, Miller, & Bruton (1993), who compared the susceptibility to *M. cannonballus* of eight non-cucurbit crops: ‘Pioneer 8358’ (sorghum), ‘Asgrow 405W’ (corn), 'Rutgers’ tomato, ‘Paymaster 145’ (cotton), ‘Era’ (wheat), ‘Cimmaron’ (alfalfa) and ‘Improved Commodore’ (bean). Their results indicated that corn, wheat and tomato cultivars showed a slight discoloration in the root system, as well as a slight reduction in the dry weight of tomato and wheat roots. Perithecia of *M. cannonballus* were also observed in bean and sorghum roots, although there was not a reduction in plant development. In a pathogenicity study with *M. cannonballus* on Solanaceae species, Tsay & Tung (1997) reported a slight rot in the root system in *S. lycopersicum*, *S. melongena* L. (eggplant), *Capsicum annuum* L. (pepper), *Brassica oleracea* L. var. *italica* (broccoli) and *B. oleraceae* var. *capitata* L. (cabbage).

Other reports of *M. cannonballus* isolated from roots of non-cucurbit crops were obtained from field surveys of *Iris* sp., *T. pratense*, *M. sativa*, *S. indicum* (Sivanesan, 1991), *Triticum* sp. (Hawksworth & Ciccarone, 1978) and *L. lasiocarpum* (Stanghellini, Kim, & Rasmussen, 1996). However, further pathogenicity studies with these hosts were not carried out.

Regarding the isolation frequency for non-cucurbit crops, Mertely, Martyn, Miller, & Bruton (1993) found the presence of *M. cannonballus* perithecia in roots of artificially inoculated plants of corn and sorghum, with an isolation frequency of 33% and 40%, respectively. These values were similar to that found here for maize, where reisolation percentages higher than 28% were observed for both cultivars and the two *M. cannonballus* isolates. In the case of sorghum, *M. cannonballus* was reisolated from roots, but with low percentages. These results suggest the potential role of these crops as hosts of *M. cannonballus*. On the other side, the same authors did not obtain reisolation of *M. cannonballus* from tomato and cotton. This fact, in the case of tomato, contradicts the results obtained in our study, although the frequency of isolation of *M. cannonballus* did not exceed 25%. Later, Tsay & Tung (1997) studying the susceptibility of Solanaceae inoculated with *M. cannonballus*, found reisolation percentages between 5 and 25% in tomato, eggplant, pepper, broccoli and cabbage roots.

In our study the cultivars of cowpea, sesame and cotton were not affected by *M. cannonballus*, being the results with cotton coincident to the results found by Mertely, Martyn, Miller, & Bruton (1993).

The differences in pathogenicity exhibited by the two *M. cannonballus* isolates on cucurbit species may be due to genetic variability, a factor that can configure specific and differentiated degrees of virulence. According to Bruton (1998), there is considerable variation in virulence among *M. cannonballus* isolates ranging from weakly virulent to highly virulent. In Brazil, Andrade et al. (2005), classified *M. cannonballus* isolates obtained from melon production areas of the states of Rio Grande do Norte and Ceará (CE), in three distinct groups of similarity, based on mycelial compatibility grouping (MCG) study. In a similar study, Bezerra et al (2013) assigned 58 isolates obtained from seven melon fields in three municipalities of Northeastern Brazil into four MCGs. Subsequently, Correia et al. (2014) investigated the fitness components of 57 isolates of *M. cannonballus* obtained from Brazilian melon fields by evaluating their mycelial growth rate, perithecia and ascospore production, sensitivity to the fungicide fluazinam and virulence to melon seedlings. A multivariate cluster analysis allowed the separation of these isolates in 18 groups of similarity.

Our results present a great concern for the melon and watermelon producers in Brazil, since corn and sorghum are the two main crops grown by them during the off-season, because they profit from the remaining fertilization in the field left by melon and watermelon crops. Thus, it is possible that maize and sorghum crops contribute to the *M. cannonballus* inoculum build-up in the soil, but further research in field conditions is needed to confirm this hypothesis.

The adoption of cultural practices such as crop rotation as a strategy contributing to minimize the economic losses caused by the attack of *M. cannonballus* to melon and watermelon crops should take into account the results here reported. Cotton, cowpea and sesame cultivars were not affected by the pathogen, so they can be considered as the recommended alternative crops to be cultivated, or in rotation with cucurbits, in *M. cannonballus* infested soils. This technique can be effective when integrated with other control measures for a sustainable MRRVD management.

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TABLE 1. Reaction of cucurbit and non-cucurbit crops to *Monosporascus cannonballus*.

Host	**Cultivar**	**Isolate CMM 2390[a]**			**Isolate CMM 3646**		
		Rank	**Mean**	**RC[b]**	**Rank**	**Mean**	**RC**
Cucumis melo	Goldex	61.75	3.50	HS	61.37	3.25	HS
	SF-69	56.62	3.25	HS	61.37	3.25	HS
Citrullus lanatus	Sugar Baby	61.75	3.50	HS	57.00	3.00	SU
	Crimson Sweet	51.50	3.00	SU	61.37	3.25	HS
Cucumis sativus	Markerter	66.87	3.75	HS	50.37	2.75	SU
	Aodai	72.00	4.00	HS	70.12	3.75	HS
***Cucurbita* sp.**	Bahiana	66.87	3.75	HS	65.75	3.50	HS
	Moranga	41.62	2.50	SU	46.00	2.50	SU
Vigna unguiculata	BRS Cauamé	4.50	0.00	HR	4.50	0.00	HR
	BRS Itaim	4.50	0.00	HR	4.50	0.00	HR
Sorghum bicolor	BRS Ponta Negra	27.62	1.75	R	30.37	1.75	R
	BRS Santa Elisa	23.75	1.50	R	25.75	1.50	R
Zea mays	BRS 205	41.50	2.50	SU	35.00	2.00	R
	AG 7098	46.50	2.75	SU	46.00	2.50	SU
Solanum lycopersicum	Santa Cruz	51.50	3.00	SU	55.87	3.00	SU
	Santa Clara	51.62	3.00	SU	54.75	3.00	SU
Sesamum indicum	G4	23.75	1.50	R	21.12	1.25	R
	Seda	23.75	1.50	R	16.50	1.00	HR
Gossypium hirsutum	BRS 335	16.00	1.00	HR	25.75	1.50	R
	BRS 286	16.00	1.00	HR	16.50	1.00	HR
χ^2			68.38*			65.62*	

[a]isolates of *M. cannonballus*; [b]RC=reaction class to *M. cannonballus*: HR= highly resistant; R= resistant; SU= susceptible; HS= highly susceptible (Armengol et al., 1998); $\chi 2$ = chi-square value significant at 5% by Kruskal-Wallis test.

TABLE 2. Frequency of isolation of *Monosporascus cannonballus* from 20 hosts inoculated with isolates CMM 2390 and CMM 3646.

Host	**Cultivar**	**Isolate CMM 2390**	**Isolate CMM 3646**
		%[a]	**%**
Cucumis melo	Goldex	53.6	39.3
	SF-69	42.8	32.1
Citrullus lanatus	Sugar Baby	53.6	53.6
	Crimson Sweet	85.7	53.6
Cucumis sativus	Markerter	39.3	42.9
	Aodai	39.3	42.9
***Cucurbita* sp.**	Bahiana	10.7	7.10
	Moranga	39.3	7.10
Vigna unguiculata	BRS Cauamé	0.00	0.00
	BRS Itaim	0.00	0.00
Sorghum bicolor	BRS Ponta Negra	28.6	17.8
	BRS Santa Elisa	14.3	3.60
Zea maiz	BRS 205	42.8	28.6
	AG 7098	53.6	42.8
Solanum lycopersicum	Santa Cruz	3.57	7.14
	Santa Clara	21.4	10.7
Sesamum indicum	G4	0.00	0.00
	Seda	3.57	0.00
Gossypium hirsutum	BRS 335	0.00	0.00
	BRS 286	3.57	0.00

[a]percentage of 28 isolation points from which *M. cannonballus* was isolated.