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OVIPOSITION PREFERENCE AND BIOLOGY OF FRUIT FLIES (DIPTERA: TEPHRITIDAE) ON GRAPE VINE GENOTYPES[1]

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ABSTRACT - Grape orchards are highly affected by oviposition of fruit flies on grape berries, which compromises the productivity and quality of the grapes. The goal of this study was to evaluate the susceptibility of American, European, and hybrid grape genotypes to *Anastrepha fraterculus* and *Ceratitis capitata* (Diptera: Tephritidae) under laboratory conditions (25 ± 2ºC, 60 ± 10% RH, and 14-hour photophase). The assays were conducted by evaluating oviposition preference through choice and no-choice (antibiosis) tests. The choice test was set up using circular arenas (diameter: 300 mm) with 10 grapes per genotype. The no-choice test was set up using 150 grapes per genotype which were placed inside plastic boxes (417 x 297 x 289 mm). After exposure of the grapes to one or two couples of fruit flies per genotype in choice and no-choice tests, respectively, the grapes were transferred to transparent plastic containers (750 mL). The number of eggs per grape and its viability were evaluated. The no-choice test also evaluated the biological cycle of the fruit flies. The assays were conducted in a completely randomized design with 15 replicates. The most preferred grapes for oviposition by *A. fraterculus* were Cabernet Sauvignon, Niagara Rosada, and BRS Cora, while *C. capitata* mainly preferred Isabel Precoce grapes. We observed the complete development of fruit flies in the Moscato Embrapa grapes, but this only occurred with *C. capitata*. All genotypes evaluated were considered susceptible to *A. fraterculus* and *C. capitata*. However, the fruit flies expressed differences in preference for oviposition and host quality.

Keywords: *Vitis* spp.. Tephritidae. Biology. Resistance of plants.

PREFERÊNCIA PARA OVIPOSIÇÃO E BIOLOGIA DE MOSCAS-DAS-FRUTAS (DIPTERA: TEPHRITIDAE) EM GENÓTIPOS DE VIDEIRA

RESUMO - No cultivo da videira a oviposição das moscas-das-frutas compromete a produtividade e a qualidade de bagas de uva. O objetivo desse trabalho foi avaliar a suscetibilidade de genótipos de uvas americanas, europeias e híbridas à *Anastrepha fraterculus* e *Ceratitis capitata* (Diptera: Tephritidae) em laboratório (25 ± 2ºC, 60±10% UR e fotofase de 14 horas) por meio de ensaios de preferência de oviposição com e sem chance de escolha (antibiose). No ensaio com chance de escolha foram utilizadas arenas circulares (300 mm de diâmetro) com 10 bagas por genótipo de uva. No teste sem chance de escolha foram utilizadas 150 bagas por genótipo de uva acondicionadas em caixa plástica (417 x 297 x 289 mm). Após a exposição a um ou a dois casais de moscas-das-frutas, por genótipo de uva nos testes com e sem chance de escolha, respectivamente, as bagas foram transferidas para potes plásticos transparentes (750 mL). Nos ensaios foram avaliados o número de ovos por baga e sua viabilidade. No ensaio sem chance de escolha também foi avaliado o ciclo biológico das moscas-das-frutas (teste de antibiose). Os experimentos foram conduzidos em delineamento inteiramente casualizado com 15 repetições. As bagas de uvas preferidas para oviposição por *A. fraterculus* foram Cabernet Sauvignon, Niágara Rosada e BRS Cora. Para *C. capitata* foi a Isabel Precoce. No genótipo Moscato Embrapa foi observado o desenvolvimento de ovo-adulto apenas de *C. capitata*. Assim, todos os genótipos foram considerados suscetíveis à *A. fraterculus* e *C. capitata*. No entanto, expressam diferenças na preferência para oviposição e na qualidade hospedeira para *A. fraterculus* e *C. capitata*.

Palavras-chave: *Vitis* spp.. Tephritidae. Biologia. Resistência de plantas.

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INTRODUCTION

Temperate fruit crops account for about 7.5% of fruit production in Brazil, and of these, grapes and apples play a very important role, as they account for around 80-85% of this production (FACHINELLO et al., 2011). The southern and northeastern regions of Brazil are the main areas for the production of grapes, and they accounted for 53% and 41% of the Brazilian production, respectively, in 2016 (MELLO, 2017). In the southern region, genotypes of American grapes (*Vitis labrusca* L.) and interspecific hybrids are dominant, and represent up to 80% of the grape vines, with the remainder made up of genotypes belonging to the European species (*Vitis vinifera* L.) (PROTAS; CAMARGO, 2011).

Fruit fly infestations in grape vines are characterized by the presence of galleries in fruits, deformations, and premature fruit drop, which are caused by the larvae (ZART; BOTTON; FERNANDES, 2011). In addition to the direct damage, the presence of punctures after oviposition by flies can contribute to the establishment of pathogenic microorganisms that cause berries to rot (MACHOTA JÚNIOR et al., 2013; 2016).

The South American fruit fly, *Anastrepha fraterculus* (Wied.) (Diptera: Tephritidae), is the species of greatest abundance and economic importance in the south of Brazil (GARCIA, NORRBOM, 2011). However, in the southern state of Rio Grande do Sul, another fruit fly, known as the Mediterranean fruit fly, *Ceratitis capitata* (Wied.) (Diptera: Tephritidae), occurs at lower densities (GARCIA; CORSEUIL, 1998; GARCIA, NORRBOM, 2011). High densities of *C. capitata* were detected near the city of Pelotas-RS in several fruit trees, representing up to 30% of the tephritid entomofauna (NAVA et al., 2008).

Winemakers adopt the use of insecticides in order to reduce the infestation of fruit flies in grape vines (FORMOLO et al., 2011). However, due to the global restrictions on their use, one of the alternatives for the management of these insect pests is the use of plants that have defense mechanisms against herbivory. These plant defense mechanisms can be of three types, known as non-preference (antixenosis), antibiosis, and tolerance (MUHAMMAD et al., 2010).

Grape genotypes show differences in susceptibility to infestation with different fruit fly species. The development of *A. fraterculus* from egg to adult was observed in Moscato Embrapa and Itália grape genotypes (ZART; FERNANDES; BOTTON, 2010; ZART; BOTTON; FERNANDES, 2011). The development of *C. capitata* was observed in the genotypes Itália, Benitaka, and Festival (GÓMEZ et al., 2008; ZANARDI et al., 2011).

It is crucial to know the susceptibility of grape genotypes to these insect pests, in order to estimate the potential damage that may be caused to grapes by fruit flies, and to assess the importance of the grape vine as a host plant. Through this process, fruit fly management strategies can be incorporated. Therefore, the present study evaluated the susceptibility of grape genotypes to *A. fraterculus* and *C. capitata* by means of non-preference to oviposition and antibiosis assays under laboratory conditions.

MATERIAL AND METHODS

Grape genotypes

The assays were conducted from October 2013 to February 2014. Grape vines used in the assay were from an espalier system, where plants were spaced 0.5 m apart each other, and there was a space of 1.0 m between rows. In order to avoid natural infestation by fruit flies, the grapes were bagged with polypropylene fabric bags (ZART; BOTTON; FERNANDES, 2011). The grape berries were harvested at either the phenological stage of full maturation, or when the total soluble solids content was 14º Bx.

The genotypes Cabernet Sauvignon, Sauvignon Blanc (*V. vinifera*), Niagara Rosada, BRS Linda, BRS Lorena, BRS Cora, Moscato Embrapa, and Maselair (Hybrids) were used for the assays with *A. fraterculus*. For the antibiosis test, the Sauvignon Blanc genotype was not used due to the low availability of grapes in that year. For the assays with *C. capitata,* the Isabel Precoce (*V. labrusca*), BRS Lorena, BRS Cora, Moscato Embrapa and Maselair genotypes were used. The same grape genotypes were not used for both species of fruit flies due to a lack of available grapes.

Fruit fly rearing

The adults of *A. fraterculus* were obtained from the laboratory, where they were reared in semi-transparent plastic cage (417 x 297 x 289 mm) with the top and the sides covered by voile fabric. Papaya fruits were provided to the flies as oviposition substrate (MACHOTA JÚNIOR et al., 2010). The diet of adults was composed of a solid diet with wheat germ, beer yeast (Bionis ® YE MF), and refined sugar at a ratio of 1:1:3 (MORELLI et al., 2012).

Adults of *C. capitata* were reared with the same procedures as described above. However, the eggs were removed from the side wall of the cages and inoculated into a 200 mm diameter petri dish containing a carrot base substrate as proposed by Teran (1977). The rearing was done under laboratory conditions in 25 ± 2ºC, 60 ± 10% RH and 14-hour photophase.

Choice test

For the choice tests, circular arenas, 300 mm in diameter and 125 mm in height (n = 15 replicates), were used. The cover of these arenas was made of voile fabric and contained a hole in the form of a sleeve. Petri dishes (100 mm) containing 10 grapes were distributed equidistantly inside of each arena. An adult couple of *A. fraterculus*, 15 to 25 days old, or *C. capitata*, 8 to 10 days old, were released inside of the cages with the aid of an insect aspirator. Each cage included one grape genotype and one fruit fly species. During the assays, two 20 mm diameter acrylic plates with solid diet and two with a hydrophilic cotton ball soaked in distilled water were placed inside these arenas. The assays were conducted under laboratory conditions in 25 ± 2ºC, 60 ± 10% RH and 14-hour photophase.

No-choice test

No-choice tests were done using 750 mL transparent plastic containers (n = 15 replicates). We placed two modified Pasteur type pipettes on the lateral side of these containers. These pipettes contained a solid diet and a cotton ball soaked in distilled water. In the interior of these containers, we placed a 100 mm petri dish with ten grape berries. Two adult couples of *A. fraterculus*, 15 to 25 days old or *C. capitata*, 8 to 10 days old, were then released inside of the cages.

After 24 hours of the berries being exposed to the fruit flies, the peel of the grapes was removed with the aid of a stylet, in order to assess the number of eggs oviposited. To evaluate the viability of the eggs, two grapes from each replicate of the no-choice test were transferred to 250 mL plastic containers containing sterilized superfine vermiculite (ZART; FERNANDES; BOTTON, 2010). The presence of larvae or hatched eggs was evaluated in these grapes after four days.

The antibiosis test was done by placing 150 grapes of each genotype in separate plastic cages with either 15 adult couples of *A. fraterculus*, 15 to 25 days old, or 45 couples of *C. capitata*, 8 to 10 days old. After six hours of exposure of the fruits to the fruit flies, the grape berries were removed from the plastic cage to avoid an excess of eggs per grape, which could reduce the availability of food for the larvae. Soon after, the grape berries were randomly distributed in 15 plastic containers (750 mL) containing sterilized superfine vermiculite.

The development of fruit fly species in grape genotypes was observed daily. The period from egg to larva was obtained using the day of the infestation until the first pupa was detected. The pupal period was estimated using the obtained pupae, which were transferred to 145 mL plastic containers with sterilized superfine vermiculite, and observed when adult emergence happened. The viability of pupae was determined by the ratio between the number of emerged adults and the number of pupae obtained. Sex ratio (sr) was also calculated using the equation [sr = females counted/ (females counted + males counted)].

The adults were separated into couples with a maximum difference of one day apart and placed in 750 mL plastic containers with two modified Pasteur pipettes (n = 15 replicates). A solid diet and a cotton ball soaked in distilled water were supplied during the assays. Daily evaluations were performed to determine the periods of pre-oviposition, oviposition, post-oviposition, female and male longevity, and number of eggs per female. In order to evaluate the number of eggs per female, artificial grapes were prepared using an agar substrate (3.0 g), distilled water (85 mL), artificial red dye (250 µL) and artificial grape aroma (200 mL) which were then coated with parafilm M® (SALLES, 1992). The data collected was also used to calculate survival rate (lx), survival of adults at a specific x and mx age, and the number of offspring generated by a female that will originate females at a specific age x (SILVEIRA NETO et al., 1976).

Physical-chemical analyses of the grape genotypes

Physical-chemical analyses were performed using 150 grapes of each genotype. The longitudinal diameter of the berries was measured using a digital caliper. The content of total soluble solids (SS) in the berries, expressed as degrees Brix, was obtained by using a digital refractometer. The pH of the berries was obtained using a digital potentiometer (RIBEREAU-GAYON et al., 1998).

Statistical analysis

The experimental design used was completely randomized. The number of eggs obtained in the choice and no-choice tests were transformed into $\sqrt[2]{x+1}$, and the egg viability percentage in arcsin $\sqrt[2]{x/100}$. The data were analyzed using analysis of variance. The means were compared using the Duncan test, and the survival rate (lx) was compared with the Log-Rank test, with a significance level of 5%. The data were analyzed using SAS statistical software, version 9.0 (SAS INSTITUTE, 2002).

RESULTS AND DISCUSSION

The first assay indicated that the most preferred grape genotypes for oviposition for *A. fraterculus* were Niagara Rosada and Cabernet Sauvignon, and these were preferred to the

genotypes Maselair and BRS Linda ($F_{3, 56}$ = 9.05, P = 0.0001). The no-choice oviposition assay, which simulates a monoculture situation, demonstrated a significant difference in which the most preferred genotypes were Niagara Rosada, Cabernet Sauvignon and BRS Linda ($F_{3, 56}$ = 5.05, P = 0.0031) (Table 1).

The second assay performed (the choice test) indicated that the most preferred grape genotype was BRS Cora, while there was no difference in preference between the BRS Lorena, Moscato Embrapa, and Sauvignon Blanc genotypes ($F_{4, 70}$ = 11.86, P = 0.0001). The no-choice assay emphasized that BRS Lorena and Sauvignon Blanc genotypes were the most and least preferred genotypes for oviposition, respectively (Table 1).

The females of *C. capitata* showed greater preference for ovipositing in the grapes of the Isabel Precoce genotype ($F_{4, 70}$ = 8.25, P = 0.0001). The no-choice test indicated that the Isabel Precoce, Moscato Embrapa and BRS Lorena genotypes were more susceptible to oviposition, and they did not differ from each other ($F_{4, 70}$ = 3.18, P = 0.0184). The Maselair and BRS Cora genotypes had the lowest number of eggs, but this was not significantly different from the BRS Lorena genotype (Table 1).

Table 1. Mean number of eggs (± standard error) of the South American fruit fly *Anastrepha fraterculus* (Wied.) and the Mediterranean fruit fly *Ceratitis capitata* (Wied.) (Diptera: Tephritidae) by grape genotypes in a choice and no-choice assay for oviposition under laboratory conditions (25 ± 2 ºC, 60 ± 10% RH and 14-hour photophase).

Fruit fly species	Assay date	Grape genotypes	Choice	No-choice
A. fraterculus	2014-02-06	Niagara Rosada	4.30 ± 0.77 a	6.69 ± 0.65 a
		Cabernet Sauvignon	3.02 ± 0.77 a	7.09 ± 0.9 a
		Maselair	1.28 ± 0.30 b	3.80 ± 0.65 b
		BRS Linda	0.61±0.20 b	5.32±0.57 a
		F-value	9.05	5.20
		Degree of freedom	3, 56	3, 56
		Probability	< 0.0001	0.0031
	2014-02-13	BRS Cora	1.61 ± 0.36 a	2.20 ± 0.32 b
		BRS Lorena	1.27 ± 0.15 b	3.86 ± 0.62 a
		Moscato Embrapa	1.23 ± 0.10 b	2.09 ± 0.28 b
		Sauvignon Blanc	1.08 ± 0.48 b	0.32 ± 0.11 c
		F-value	11.86	17.49
		Degree of freedom	3, 56	3, 56
		Probability	< 0.0001	< 0.0001
C. capitata	2014-02-17	Isabel precoce	2.36 ± 0.40 a	1.02 ± 0.37 a
		Moscato Embrapa	1.16 ± 0.31 b	0.92 ± 0.14 a
		BRS Lorena	0.73 ± 0.19 b	0.44 ± 0.26 ab
		BRS Cora	0.62 ± 0.19 b	0.28 ± 0.11 b
		Maselair	0.38 ± 0.11 b	0.24 ± 0.10 b
		F-value	8.25	3.18
		Degree of freedom	4, 70	4, 70
		Probability	< 0.0001	0.0184

Means followed by the same letters in the column do not differ from each other by Duncan's test at 5% probability.

Several factors can influence the oviposition behavior of fruit flies under natural or artificial host conditions, including host quality, color, maturation, size, firmness of the fruit, and the incidence of pheromone marking (DÍAZ-FLEISCHER; ALUJA, 2003). The most preferred genotypes for *A. fraterculus* oviposition were those of blue or crimson coloration, such as Niagara Rosada (crimson), Cabernet Sauvignon (blue), and BRS Cora (blue). The most preferred genotype for *C. capitata* oviposition was the Isabel Precoce genotype, which has blue grape berries.

The two choice tests performed with *A. fraterculus* indicated that the highest number of eggs were observed in Niagara Rosada and BRS Cora grapes, which had grapes with the largest diameter (Tables 1 and 2). This may indicate a searching behavior for larger hosts, due to the possibility of greater availability of food. However, the Cabernet Sauvignon genotype had grapes with one of the smallest diameters, and it did not differ from the Niagara Rosada genotype in the number of eggs per grape.

This behavior was also observed when soluble solids content was evaluated. The genotypes Niagara Rosada and BRS Cora had intermediate values of 16.3 and 18.4 ºBx, while Cabernet Sauvignon had the lowest value of soluble solids (12.5 ºBx). The Sauvignon Blanc genotype had the lowest number of eggs per berry, and the highest soluble solids value (21 ºBx) (Table 1 and 2).

C. capitata displayed the same behavior as *A. fraterculus*. Larger diameter grape genotypes, such as Isabel Precoce, had the highest number of eggs. However, there was a low preference for oviposition even in berries of larger diameter genotypes, such as BRS Lorena and BRS Cora (Table 2). For the soluble solids parameter, the Isabel Precoce genotype had the lowest value of degrees Brix (14.0 ºBx).

The results indicate the possibility that an interaction among physical-chemical factors affects how fruit flies choose oviposition sites. This interaction can be different between fruit fly species, and may be dependent on the host plant. A study on pear fruits of the Packhams and Williams genotypes showed that the complete development of *A. fraterculus* occurred only in fruits which were 54.9 and 63.5 mm in diameter, respectively, and which had higher soluble solids content (NUNES et al., 2015). The increase in soluble solids content in kiwi fruits was also indicated as an important factor associated with the development of *A. fraterculus* under laboratory conditions (LORSCHEITER et al., 2012).

Table 2. Means (± standard error) of physical-chemical parameters of grape genotypes.

Assay date	Grape genotypes	Soluble solids (ºBx)	pH	Longitudinal diameter (cm)
2014-02-06	Niagara Rosada	16.3±0.32b	3.5±0.01a	1.8±0.01a
	Cabernet Sauvignon	12.5±0.37c	3.0±0.01c	1.2±0.01c
	Maselair	15.7±0.32b	2.9±0.02d	1.2±0.01bc
	BRS Linda	19.0±0.51a	3.3±0.02b	1.2±0.01c
	F-value	45.68	308.89	557.41
	Degree of freedom	3, 80	3, 80	3, 50
	Probability	< 0.0001	< 0.0001	< 0.0001
2014-02-13	BRS Cora	18.4±0.75b	3.3±0.02b	1.5±0.03a
	BRS Lorena	18.9±0.58ab	3.2±0.003b	1.3±0.02b
	Moscato Embrapa	17.0±1.00b	3.4±0.03a	1.2±0.02b
	Sauvignon Blanc	21.0±0.32a	3.3±0.02b	1.2±0.02b
	F-value	5.30	6.82	27.71
	Degree of freedom	3, 80	3, 80	3, 50
	Probability	0.0264	0.0135	< 0.0001
2014-02-17	Isabel precoce	14.0±0.00b	3.3±0.01ab	1.6±0.03a
	Moscato Embrapa	17.0±1.00a	3.40±0.03a	1.2±0.02bc
	BRS Lorena	18.9±0.58a	3.2±0.00b	1.3±0.02a
	BRS Cora	18.4±0.75a	3.3±0.02ab	1.6±0.03a
	Maselair	17.6±0.23a	3.1±0.07c	1.1±0.01c
	F-value	9.29	7.79	47.73
	Degree of freedom	4, 10	4, 10	4, 70
	Probability	0.0021	0.0040	< 0.0001

Means followed by the same letters in the column do not differ from each other by Duncan's test at 5% probability.

There was no significant difference in viability of *A. fraterculus* eggs oviposited in grapes of the BRS Linda, Niagara Rosada, Cabernet Sauvignon, and Maselair (66% to 44%) genotypes ($F_{3, 55}$ = 2.65, P = 0.0581) (Figure 1A). The second assay indicated that BRS Lorena and BRS Cora genotypes had the highest percentages of egg viability (94% and 92%, respectively), and they did not differ from the Moscato Embrapa genotype, which had an intermediate egg viability value (64%). Egg viability did not differ between the Moscato Embrapa and Sauvignon Blanc genotypes, which both had an egg viability of approximately 50% ($F_{3, 37}$ = 4.74, P = 0.0068) (Figure 1B).

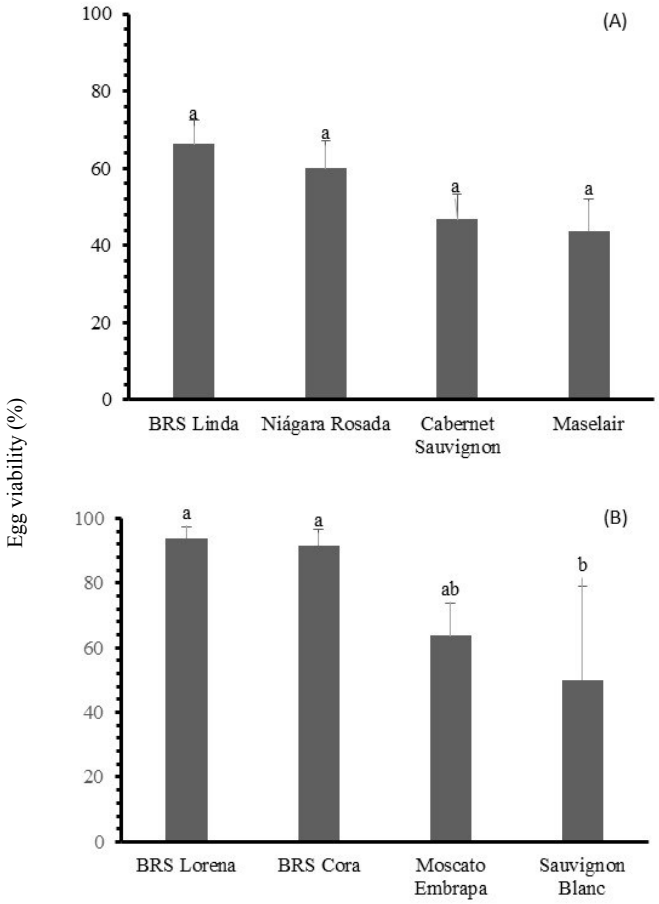

Figure 1. Viability of *Anastrepha fraterculus* eggs (Wied.) (Diptera: Tephritidae) in grape genotypes under laboratory conditions (25 ± 2ºC, RH of 60 ± 10% and 14-hour photophase). Grape berries were infested on (A) 2014-02-06 and (B) 2014-02-13. Means followed by the same letter do not differ by Duncan's test at 5% probability.

The assay with *C. capitata* demonstrated that Maselair and BRS Cora genotypes had very distinct values of egg viability percentages, which were 100 and 19% respectively. BRS Lorena, Moscato Embrapa, and Isabel Precoce genotypes had intermediate egg viability values (80 to 31%) ($F_{4, 27} = 5.40$, $P = 0.0025$) (Figure 2).

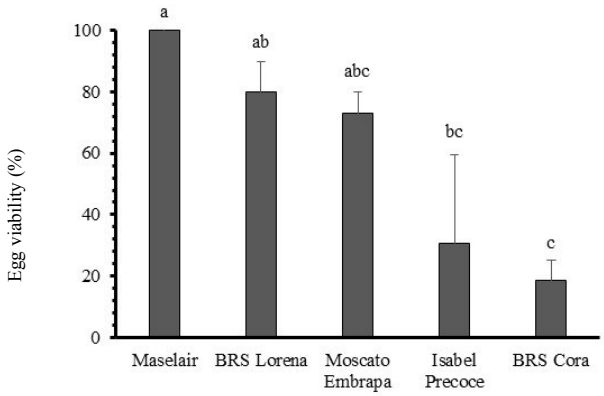

Figure 2. Viability of *Ceratitis capitata* eggs (Wied.) (Diptera: Tephritidae) in grape berries under laboratory conditions (25 ± 2ºC, 60 ± 10% RH and 14-hour photophase). Means followed by the same letter do not differ by Duncan's test at 5% probability.

According to Vera et al. (2014) the pH also influenced egg viability of *A. fraterculus*, which was lower at a pH of 3.5 (16% to 31%), and higher at a pH of 4.0 and 4.5 (42% to 59%). However, in the present work *A. fraterculus*, even at low pH conditions (below 3.5) had a high egg viability (above 44%). According to Papachristos, Papadopoulos and Nanos (2008), pH values below 4.0 are considered ideal for the development of *C. capitata*. Although all genotypes tested for *C. capitata* had pH values between 3.1 and 3.4, egg viability was still low (between 31% and 19% for Isabel Precoce and BRS Cora, respectively).

Egg viability of *A. fraterculus* was observed in all grape genotypes, although the complete development from egg to adult was not observed in any of the grape genotypes tested (Cabernet Sauvignon, Niágara Rosada, BRS Linda, BRS Lorena, BRS Cora, Moscato Embrapa, and Maselair). Some previously published papers reported the development of this fruit fly species in the Moscato Embrapa and Itália (*V. vinifera*) genotypes, both of which have a white exocarp color at the full maturation stage (ZART; FERNANDES; BOTTON, 2010; ZART; BOTTON; FERNANDES, 2011). Furthermore, these same authors observed the oviposition of *A. fraterculus* in the genotypes Niagara Rosada, Cabernet Sauvignon, and Isabel Precoce, but they did not detect the development of larvae, corroborating the results found in the present study.

C. capitata only completed post-embryonic development in the Moscato Embrapa genotype. There was no post-embryonic development in the Isabel Precoce, BRS Lorena, BRS Cora and Maselair genotypes (Table 3).

Table 3. Biological parameters of the Mediterranean fruit fly *Ceratitis capitata* (Wied.) (Diptera: Tephritidae) in grapes of the Moscato Embrapa grape genotype (*Vitis vinifera*) under laboratory conditions (25 ± 2ºC, 60 ± 10 % RH and 14-hour photophase).

Biological parameters	n[1]	Mean ± SE[2]	Variation interval
Egg-larva period (days)	41	18.8±1.49	15-27
Pupa period (days)	18	10.6±0.22	9-13
Pupa Viability (%)	-	50.0±10.00	-
Egg-adult period (days)	18	30.9±0.95	25-36
Sex ratio	18	0.51±0.14	0.25-1
Pre-oviposition period (days)	7	9.6±2.08	0-16
Oviposition period (days)	7	23.9± 8.63	0- 57
Post-oviposition period (days)	7	2.0±0.65	0-4
Number of eggs per female	7	50.3±15.82	0-97
Male longevity (days)	7	37.0±16.00	3-109
Female longevity (days)	7	41.1±8.92	12-78

[1] Number of insects observed
[2] Mean ± Standard error

The period from egg to larva, pupa and egg to adult of *C. capitata* in grape berries of the Moscato Embrapa genotype lasted 18.8, 10.6, and 30.9 days respectively, which is similar to the results found by Zanardi et al. (2011) in grapes of the Itália genotype (18.2, 11.0, and 32.6 days respectively). According to Gómez et al. (2008) the duration of the period from egg to adult for *C. capitata* was 29.8 and 27.4 days in the Benitaka and Festival grape genotypes, respectively.

There was no difference between the longevity of females and males of *C. capitata* in the Moscato Embrapa genotype, which was 41.1 and 37.0 days respectively (χ^2 = 0.0028, DF = 1, *P*=0.9580). When the flies were 35-36 days old, female survival rate was 50%, and 67% of the eggs were already oviposited (Figure 3).

The total fecundity of *C. capitata* in the Moscato Embrapa genotype was 50.3 eggs per female, which is lower than the values observed in other studies. The total fecundity of *C. capitata* from post-embryonic development in berries of the Benitaka and the Festival genotypes were 200 and 153 eggs respectively (GÓMEZ et al., 2008). According to Zanardi et al. (2011), the fertility of the Mediterranean fruit fly in the Itália genotype was 216.8 eggs per female, which is lower than the value observed in flies on, for example, peach fruits (434.5 eggs per female).

The evaluation of egg viability in the no-choice test for oviposition showed that the non-development of these species of fruit flies occurred mainly due to the high mortality in the post-embryonic stage. This fact may indicate the presence of defensive substances or poor nutritional quality of the host, especially in blue grape berries. According to Comarella et al. (2012), the blue grape genotypes contain a higher quantity of phenolic compounds, such as anthocyanins, than green peel genotypes.

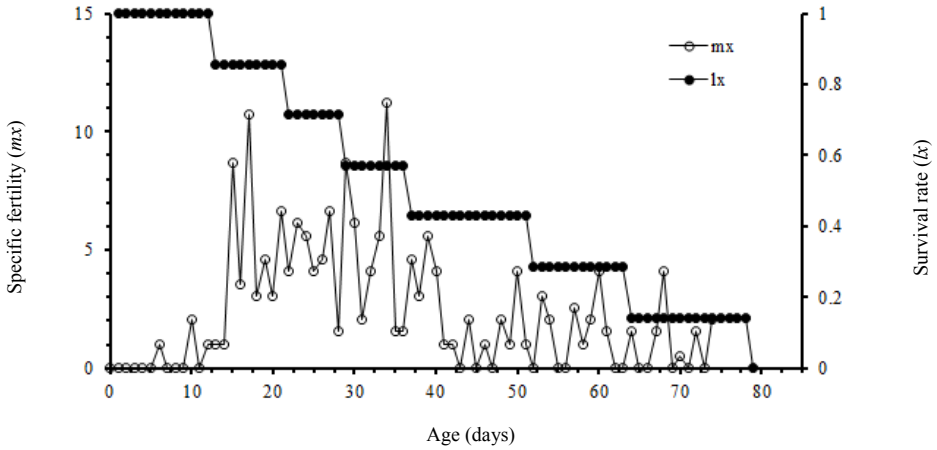

Figure 3. Specific fertility (mx) and female survival rate (lx) of the Mediterranean fruit fly Ceratitis capitata (Wied.) (Diptera: Tephritidae) from the post-embryonic development in grapes of the Moscato Embrapa grape genotype (Vitis vinifera) under laboratory conditions (25 ± 2ºC, 60 ± 10% RH and 14-hour photophase).

Baker (1945) observed oviposition hosts of a Mexican *A. fraterculus* population, and reported that grapes were the most preferred fruit for oviposition, compared to guava, loquat, and peach, although the insects were not able to complete their larval stage in grapes. Thus, the results suggest that there are hosts that are more favorable for fruit fly reproduction than grapes, indicating that this fruit is a secondary host for *A. fraterculus* and *C. capitata*.

Similar results were also found for other species of fruit flies. As observed by Andreazza et al. (2016), grapes were not considered a suitable host for the development of the spotted-wing drosophila, *Drosophila suzukii* (Matsumura) (Diptera: Drosophilidae), which was recently identified in Brazil. The oviposition was between 0.2and 4.6 eggs per grape in genotypes which were considered susceptible, but adult emergence did not exceed 5.7%. There was no oviposition in the genotypes which were considered resistant, among them, the Itália, Isabel and Niagara Rosada genotypes.

Although grapes may be considered a secondary host for fruit flies, in the present work, all genotypes were considered to be susceptible to *A. fraterculus* and *C. capitata*. This is due to the fact that these insect species can compromise the quality of the grapes by indirectly damaging fruit berries due to fungal infections in the pre-harvest stage (ENGELBRECHT; HOLZ; PRINGLE, 2004; RODITAKIS; TSAGKARAKOU; RODITAKIS, 2008; MACHOTA JÚNIOR et al., 2013).

Field conditions demonstrated that the mechanical action of the *A. fraterculus* ovipositor increased the penetration of *Botrytis cinerea*, *Glomerella cingulata* and microorganisms which cause sour rot in the Itália grape genotype. Thus, for the right management of fruit flies, the use of integrated pest and disease management programs is recommended (MACHOTA JÚNIOR et al., 2016). Furthermore, field experiments need to be done in order to better evaluate the preference of fruit fly oviposition in different grape genotypes, and to link this to the epidemiology of fungal diseases in grape berries.

CONCLUSIONS

The genotypes Cabernet Sauvignon, Niagara Rosada, and BRS Cora were the most preferred for *A. fraterculus* oviposition. However, the development of *A. fraterculus* larvae was not observed in any of the genotypes evaluated (Cabernet Sauvignon, Niagara Rosada, BRS Linda, BRS Lorena, BRS Cora, Moscato Embrapa and Maselair). The Isabel Precoce genotype was the most preferred for *C. capitata* oviposition. Grape berries of the Moscato Embrapa genotype were the only ones that allowed the development of larvae and pupae of *C. capitata*.

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