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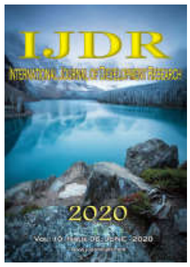

RESEARCH ARTICLE OPEN ACCESS

FLOATING POPULATION OF *Diaphorina citri* IN DIFFERENT VARIETIES OF SWEET ORANGE (*Citrus sinensis*) PRODUCED IN COMMERCIAL ORCHARD

[1]Renan Matos Cestaro, [1]Gabriel Pereira Pacheco dos Santos, [1]Mateus Luiz de Oliveira Freitas, [1]Flávia Helena de Moura Libório, [2]Gisele Caroline Novakowski, [3]Anny Rosi Mannigel, *[3]Graciene de Souza Bido and [4]Aline Maria Orbolato Gonçalves Zuliani

[1]Student of University Center of Maringá - UNICESUMAR, Maringá-Paraná, Avenue Guedner, 1610, Maringá, Paraná, Brazil; [2]Professor in the Department of Biological Sciences, University Center Ingá, PR 317, 6114, Industrial Park 200, Maringá, Paraná, Brazil; [3]Professor in the Master Program in Science, Technology and Food Safety, University Center of Maringá - UNICESUMAR. Researcher at ICETI - Cesumar Institute of Science, Technology and Innovation, Avenue Guedner, 1610, Maringá, Paraná, Brazil; [4]Professor in the Department of Agronomy, University Center of Maringá – UNICESUMAR, Avenue Guedner, 1610, Maringá, Paraná, Brazil

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Corresponding author: Graciene de Souza Bido,

ABSTRACT

Brazil is one of the largest citrus producers in the world and also the largest exporter of orange juice. At present, Huanglogbing is the main disease of citriculture, due to its rapid spreading and provoked damages. The spread of the disease occurs through the psyllid *Diaphorina citri*. The main objective of monitoring population fluctuation is to detect or determine prematurely the incidence of the pest. The objective of this study was to evaluate the population fluctuation of the psyllid in commercial sweet orange orchard (*Citrus sinensis*) containing different citrus varieties in the state of Paraná. The evaluated varieties were: Valencia, Pera Rio, Folha Murcha, Rubi and Ponkan grafted on Rangpur lime (*Citrus limonia*), and with an average spacing of 6.5m between row and 3.0m between plants, totaling an area of 14.24 ha. With the aid of a magnifying glass the insects were identified and counted in each of the traps. The insects presented different behavior in the different varieties in relation to the traps. In the Valencia variety there was a higher average capture of psyllids (4.11) compared to the other varieties. In all varieties, larger adult psyllid catches were noted on the outskirts of the plots when compared to the traps positioned inside the plots. The altitude, temperature, relative humidity (RH) of the air and precipitations, vegetative flows are factors that can influence the occurrence, development and capture of *D. citri*.

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INTRODUCTION

Citriculture is increasingly gaining space and importance in Brazilian agribusiness with market expansion and enhancement of such activity. In Brazil, there are seedlings production in certified nurseries, citrus fruit cultivation, juice production and international distribution channels that bring the products to the European, North American and Asian consumers (Neves et al., 2010). Brazil is one of the largest citrus producers in the world and also the largest exporter of orange juice, meeting a demand from several countries. Citrus exports totaled 18.6 million tons in the 2017 harvest, Brazil accounted for 50% of world production of orange juice, exporting 98% of its production (Neves et al., 2010; Instituto Brasileiro de Geografia e Estatística, 2018). A survey conducted by IBGE in February 2018 showed the closure of the 2017 Orange Harvest, the following results: an area harvested in Brazil in 2017 was 622 839 hectares and in 2016 a harvested area was of 629,770 hectares. Compared to 2016, 2017 fell by 1.1%. Production for 2017 had a return compared to 2016, from 18 666 928 tons to 18 387 101 tons, a reduction of 1.5%. These occurrences may be involved with factors such as: replacement of areas affected by orange cultivation by other crops, inadequate crops, among others. The average of hectares was 29.52 tons.

In the national production, the state that stands out is São Paulo, with approximately 14 300 000 tons and the state of Paraná with a production of approximately 857 050 tons. The rest of Brazil's production is basically distributed in the states of Bahia, Minas Gerais, Sergipe and Rio Grande do Sul, and distributed with less relevance in almost all federation units (IBGE, 2018). Brazilian citrus has had a great development in recent years and also a rapid expansion to new areas, this advance could not be greater due to the increase of diseases and pests, mainly because while some pests cause direct damage, others cause indirect damage for being vectors of plant pathogens (Parra et al., 2003; Gravena, 2005). Huanglongbing (HLB) or Greening is currently the main disease of citrus, due to its rapid spread and damage caused, lack of curative control standards, lack of resistant commercial varieties and a large amount of eradicated citrus plants, which eventually compute increased production costs (Bové, 2006). In the last decade, approximately 40 million citrus plants have been eradicated, pests and diseases being the cause of this eradication, with losses of 80 million boxes per year by 2010 (Neves et al., 2010). According to Graça et al. (2016), the symptoms of greening appear initially in a sectoral way, in a certain branch, the main symptom is the appearance of an irregular leaf blade spot. As symptoms progress in the plant, the leaves of the affected parts may fall and the pointer may die. Fruits of affected plants manifest irregular maturation, are smaller, asymmetrical and deformed. Plotto et al. (2010) report that fruits show lower soluble solids content and higher acidity, thus compromising fruit quality.

The etiological agent of HLB is the bacterium *Candidatus liberibacter*. In Brazil there are two subspecies of the bacterium known as *Candidatus Liberibacter asiaticus* and *Candidatus Liberibacter americanus*, related to HLB (Coletta-Filho et al., 2004; Teixeira et al., 2005). The spread of the disease occurs through the psyllid *Diaphorina citri* (Hemiptera: Liviidae) (Yamamoto et al., 2006). There is a great concern about the spread of the pest in orchards (Fernandes, 2004) and the extensive host chain of the genus *Citrus* and related plants, such as *Murraya paniculata*, used as an ornamental plant in Brazil and hosting the psyllid, facilitating its spread. dissemination (Lopes, 2006; Parra et al., 2010). *Diaphorina citri* (Hemiptera: Psylloidea: Liviidae) is one of the main pests in citrus. Psyllid *D. citri* is a sucking insect, adults of this insect are 2.8 to 3.2 mm long, brownish in color, the broadest antenna in the apical half and a brown mottled band extending around the border of the outer half of the wing, the antennas have black tips and two small dark spots in the central segments (Fernández and Miranda, 2005). The population fluctuation of *D. citri* is directly influenced by budding flows, temperature and relative humidity (Hall et al., 2008). Yamamoto et al. (2001) found that a larger adult population of psyllids occurs in the Brazilian spring and summer, and in the fall and winter of the same year there is a smaller population, possibly due to a smaller flow of budding. To know the ideal moment of insecticide application for *D. citri* control, the best option is the population monitoring of the psyllid that can be done through yellow adhesive traps and also by the 'pesters' (Yamamoto and Miranda, 2009). These traps are based on the insect's attraction to color, being limited to the psyllid's visual field (Miranda et al., 2011). The main objective of population fluctuation monitoring is to detect or prematurely determine the incidence of the pest or even to establish when the pest is not present in the orchards and with this, it can represent a huge reduction in insecticide use, also define the distribution of the insect in a geographical area and still establish action thresholds and the best control periods (Vilela and Della Lucia, 2001). It is of great importance the distribution of traps for the capture of psyllids, where large amounts of psyllids caught in the border of the field are observed (Menezes, 2011). The same found that there is no difference in catching psyllids at different heights, when related to heights of 1.5 and 3.0 meters in the crowns of citrus plants. Based on the information cited, it can be seen that it is of great importance to improve the *D. citri* monitoring system. Thus, the research aimed to monitor adult *D. citri* with yellow adhesive traps to verify which periods of the year occur the most frequently the incidence of this pest in different citrus varieties of different ages and sizes in commercial citrus orchard in the municipality of Guairaçá, state of Paraná.

MATERIAL AND METHODS

Field data were obtained from a citrus commercial area located in northwestern Paraná, in the municipality of Guairaçá, (Latitude: 22 ° 56'59.08” S; Longitude: 52 ° 45'33.91” W), sandy soil region (Caiuá Sandstone). Five plots of citrus plants were evaluated for the study from October 2017 to June 2018. Plants of the Valencia, Pera Rio, Folha Murcha, Rubi [*Citrus sinensis* (L.) Osbeck] and Ponkan [*Citrus reticulata* Blanco] varieties grafted on Rangpur lime0 [*Citrus limonia* (L.) Osbeck], which varieties were planted in an average spacing of 6.5m between row and 3.0m between plants, totaling a total evaluated area of 14.24 hectares. Around the entire property were planted windbreak barriers of the species: Eucalyptus, Silk Oak and Sabiá, and the surroundings of the property consists of areas of beef cattle. Each field has different area and number of plants, Field 1 - Valencia with an area of 2.4 hectares and 1230 plants, Field 2 - Ponkan area of 2 hectares and 1025 plants, Field 3 - Pera Rio area of 4.2 hectares and 2154 plants, Plot 4 - Folha Murcha, area of 2.9 hectares and 1487 plants and Plot 5 – Rubi with an area of 2.7 hectares and 1385 plants. As it is a commercial orchard, the experimental area received conventional treatments, that is, the use of insecticides to control psyllids and, during the experiment period, fungicides, herbicides and fertilizers were also applied. The population of *D. citri* was monitored by adult capture using ISCA yellow adhesive traps with entomological glue on both sides and dimensions of 15.5 x 10.0cm. The traps were set outside the treetops at an average height of 1.50 meters from the ground and distributed on the outskirts. One tag was placed inside the plots, totaling nine tags per plot, distributed evenly across all evaluated plots, where the number 1, 2, 3, 4, 6, 7, 8 and 9 labels were positioned at the border and number 5 within the field. Because it is a field with plants with a lower planting age compared to other fields, the field of the Ponkan variety has plants smaller than the other varieties, the plants have an average height of 1.00 meter and in that case, the trap was installed at the plant pointer, at 1.00 meters above the ground.

The labels were changed every fortnight, and the identification took into account their morphological characteristics, using a magnifying glass for vector counting. The meteorological data of temperature and precipitation were obtained through the IAPAR (Paraná Agronomic Institute), with readings taken in the Experimental Unit of the city of Paranavaí - PR. To study the population fluctuation of vectors, *D. citri* specimen number data were obtained by counting over time adults caught in each trap at the points where they were installed for insect collection.

RESULTS

The insects presented different behavior in different citrus varieties in relation to the traps, it can be observed that the traps positioned at the ends of the plots presented insect capture. However, traps positioned within the field of all varieties did not capture any specimens of *D. citri*. This may be due to the use of insecticides in the commercial orchard. However, other authors report lower insect capture within the field, which corroborates data from Boina et al., 2009; Tomaseto et al., 2015; Sétamou and Bartels, 2015. Sétamou et al. (2012) report that *D. citri* is a diurnal insect with high phototropism, which could explain its preference for trees in the border of the fields. In addition, results obtained by Leong et al. (2018) evaluating the distribution of *Diaphorina citri* in orchard, indicated under different parameters an aggregate pest pattern, which is confirmed with the study, in which it verified an aggregation outside the field. Table 1 shows that the trap that presented the largest insect capture was located on the outside of the field (traps number 9 or 1) for all varieties studied. The Valencia variety showed the highest captured insect index with an average of 4.11. It was also found that in trap number 5, located inside the field, there was no capture of psyllids in any of the varieties. According to the evaluation periods that involved from October 2017 to June 2018, it was possible to verify, through Figure 1, that from October 2017 to December 2017 there was a higher number of insect capture, probably due to the higher vegetative development of the plants and high temperatures. From March to June, where there are lower temperatures (Figure 2) and fewer new budding, there was less

Table 1. Average capture of psyllids per trap in each citrus cultivar evaluated

Traps	Folha Murcha	Pera Rio	Ponkan	Rubi	Valencia
1	2.72	2.78	2.17	3.39	3.11
2	0.28	0.39	0.33	1.11	1.44
3	2.56	2.22	0	2.78	2.78
4	2.06	2.11	0.89	2.33	2.67
5	0	0	0	0	0
6	1.78	1.89	0.72	2.16	2.5
7	2.78	2.61	2.11	3	3
8	0.33	0.33	0.33	1.83	2.16
9	2.94	2.72	1.44	3.39	4.11

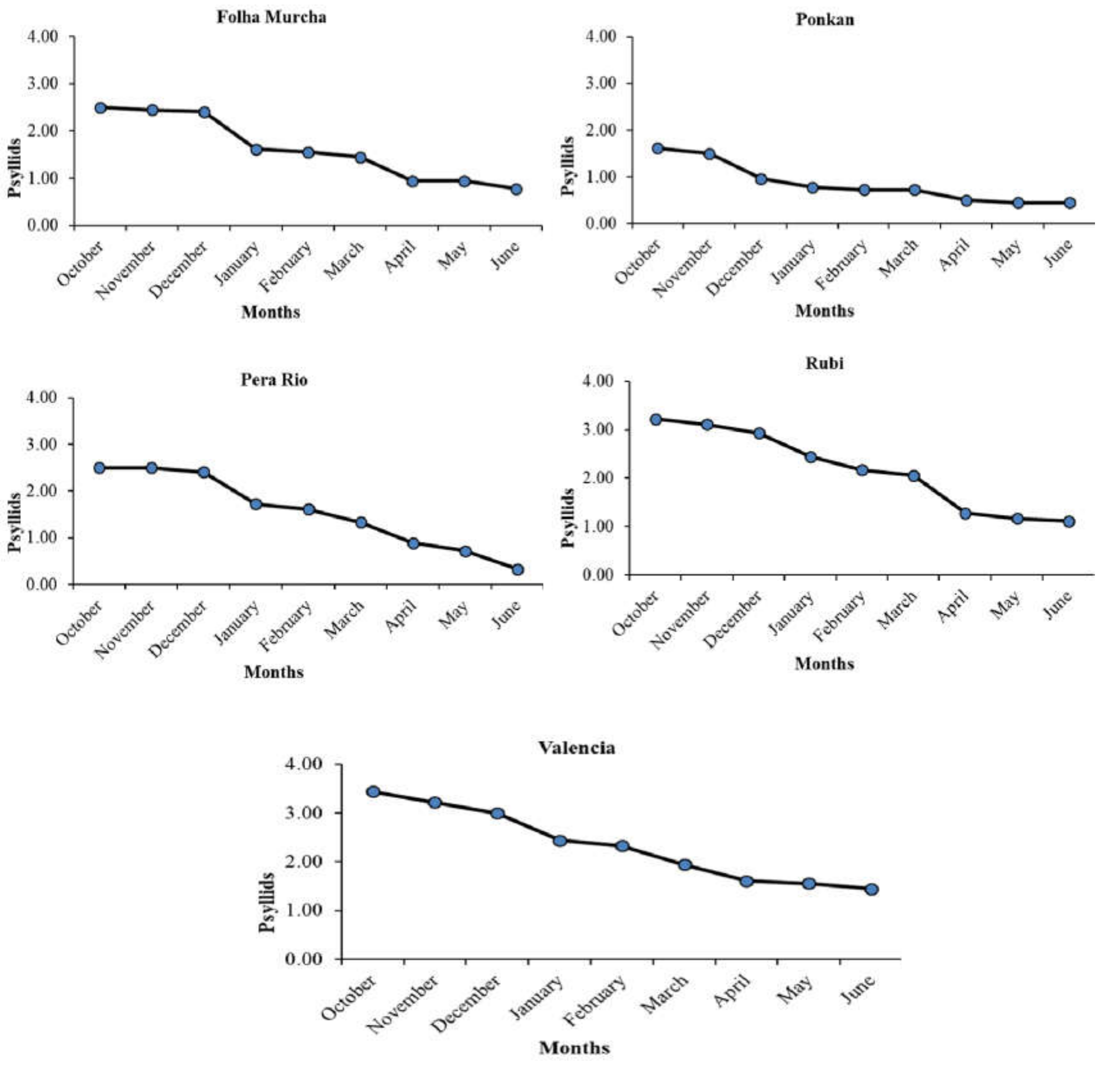

Figure 1. Average capture of *D. citri* by variety from October 2017 to June 2018

insect capture in the citrus varieties. It was also possible to verify that from October to December 2017 there was a reasonable precipitation and greater insect capture. From January 2018 onwards, when precipitation started to increase, and the maximum rainfall was evidenced, insect capture began to fall (Figure 3).

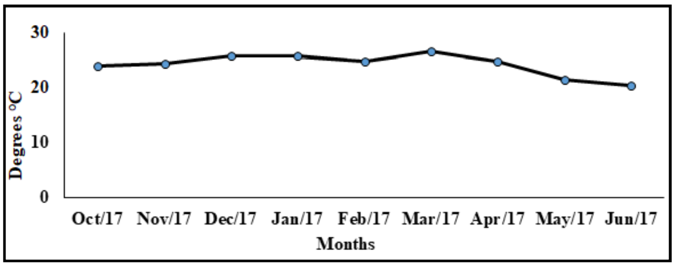

Figure 2. Average temperature in Celsius degree from October 2017 to June 2018

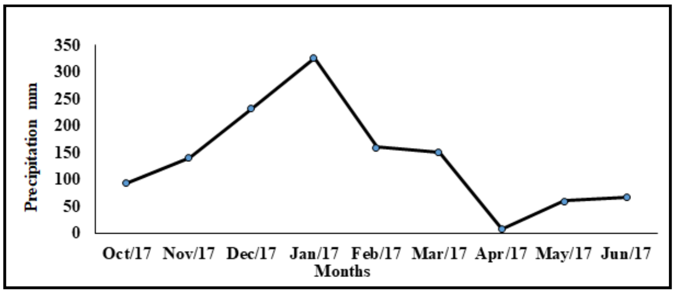

Figure 3. Precipitation in millimeters from October 2017 to June 2018

DISCUSSION

According to Artiles (2017), altitude, temperature, relative humidity (RH) and rainfall and vegetative flows are factors that may influence the occurrence, development and capture of *D. citri*. Also, according to Aubert (1987), very high temperatures (above 32-34 ° C) and very low temperatures (below 2.5 ° C), as well as relative humidity above 87-90% prevent psyllid development. The same author also reported that months with precipitation above 150 mm are associated with the fall of the *D. citri* population, as eggs and first instar nymphs can be "washed away" from the plant surface, which influences a smaller population of adult insects. Yamamoto et al. (2001) also reported that during rainy months the adult population decreases. According to Parra et al. (2010), both nymphs and adults are generally associated with new budding, which are used for feeding. In the absence of these, they can use mature leaves for feeding, so the availability of budding is a limiting factor in oviposition, as adult females of this species only lay eggs under these conditions. Beloti et al. (2013) reported that the psyllid population fluctuation in different citrus varieties resulted in a higher population peak in the Brazilian spring and summer, due to higher emission of vegetative flow from the plant. Similar results were obtained by Farias et al. (2018) where population peaks occurred in spring, summer, and early fall in Brazil in November, December, and March. Moreover, these same authors concluded that precipitation contributed to the population increase of adult insects, because the adult has high longevity and hides in the abaxial face of the leaves in periods of rain, which does not occur with nymphs and eggs. Further studies on the biology of *D. citri* are of paramount importance to citrus, as the disease does not have effective control and studies such as this can provide better answers on insect behavior.

Conclusions

Greater capture of adult psyllids occurred in the yellow adhesive traps located on the border of the plots and there was no capture in the internally located traps in the plots evaluated. In addition, it was observed that in all varieties from October to December the highest average catches of insects occurred, due to a greater presence of new buddings and a direct influence of higher temperatures and reasonable rainfall.

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