Population fluctuation of fruit fly *Anastrepha* spp. (Diptera: Tephritidae) in guava accesses produced in organic system

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**ABSTRACT**

Guava presented prominence among the tropical fruits. Guava exports are still unimpressive due to quarantine pests; among them is the fruit fly. The present research had as objective to evaluate the population fluctuation of fruit flies *Anastrepha* spp. and the fruits infestation caused in guava accesses cultivated in organic system and to study the possible correlations between this pest and meteorological factors. For the study of population fluctuation, 20 yellow sticky traps were used. The reviews were initiated in April, 2013 and duration of a year. The traps were kept in the field for the entire duration of the experiment, and the evaluations were made every 15 days, during replacement of traps for new ones. With the data, simple correlations were calculated between the fruit flies of the genus *Anastrepha* spp., the temperature and precipitation. Nine fruits per accession at the stage of maturation were evaluated for fruit fly infestation by the longitudinal cutting of fruit. The averages were compared by Scott-Knott test at 5% probability. The genus *Anastrepha* was found in greater quantity and there is no correlation between the meteorological factors and population fluctuation of *Anastrepha*. Also was found some individuals of the species *Ceratitis capitata*. Most of the fruits of the evaluated accesses presented high infestations by fruit flies. The accesses Torrão de Ouro, Supreme BA, L2P4 and Supreme, also showed low numbers of fruit attacked.

**Key words:*** Psidium guajava, varietal resistance, temperature, precipitation.

**INTRODUCTION**

Guava fruit presents prominently among the tropical fruit, due mainly to the large variety of products and subproducts, uses and forms of consumption (Campos et al., 2013). In Brazil, commercial guava orchards are concentrated mainly in the Southeast and Northeast, being the States of São Paulo and Pernambuco, the largest producers of guava fruit (Francisco et al., 2010).

Despite the economic importance on the world stage, the export of Brazilian guava in nature is still unimpressive, making marketing almost exclusively dependent on the internal market (Costa et al., 2007). According to Dória et al. (2004), the main obstacle to exports of these fruits is the quarantine barriers by importing countries to prevent the fruit flies *Ceratitis capitata* (Wiedemann, 1824) and *Anastrepha* spp. (Diptera: Tephritidae).

Fruit flies are limiting factors in the production of guava. The direct damage of fruit flies is caused by the female and the larvae developed within the fruit. The female penetrates the fruit epidermis with her ovipositor to put eggs through the puncture by skin fruit and after the eclosion, the larvae consumes the pulp of the fruit making them inappropriated both for fresh consumption and industrialization. Indirectly the damage caused through the hole made for oviposition and larval feeding, makes easy the contamination with micro-organisms that provoke the root of attacked fruits (Nascimento et al., 2000).

Many fruit trees of the family Myrtaceae are primary...
host of fruit flies (Silva et al., 2010; Silva et al., 2011; Birk and Aluja, 2011). In Brazil, C. capitata (Wied.) and more than 11 species of Anastrepha have already been reported infesting guava fruit (Souza et al., 2009; Pereira et al., 2012; Jesus et al., 2012).

The genetic improvement of fruit trees in search of varieties resistant to fruit flies is one of the best alternatives of control, being of great interest to organic farming system, where the use of synthetics agricultural products is not allowed.

One of the reasons for the organic farming system of guava still unexplored is due to the needs of major care mainly in phytosanitary areas. In addition, there is much interest in developing new technologies to increase agricultural yield without considering the impacts in human health and worker safety (Frank et al., 2004).

Climate components can directly or indirectly influence the behavior of agricultural pests. These elements act directly on mortality and on the performance of pests through changes in oviposition, feeding, growth and migration (Hopkins and Memmot, 2003). The temperature and relative humidity, as well as, the precipitation are the main climatic elements related to population dynamics of agricultural pests (Wallner, 1987). The insects are adapted to specific variations of temperature and the temperature is often the most damaging environmental factor influencing their populations and distribution (Damos and Savopoulou-Soutiani, 2011).

According to Salles (2000), the temperature is a factor that has a lot of influence on the biology of fruit flies and at temperatures below 10°C and greater than 35°C there was no development of any of the phases of the life cycle of Anastrepha fraterculus (Wied.). The pluvial precipitation and relative humidity can still exert influence on the development of flies since the pupa phase occurs in the soil and need for moisture to promote emergence of adults (Aluja, 1994).

It should be emphasized that the population fluctuation of flies over a period, depends on a set of related factors, such as host fruits, time of year and alternate hosts, among others. Thus, rainfall can lead to a greater quantity of fruits, which may offer a greater supply of development sites for tephritids larvae. Therefore, various biotic or abiotic factors may have influence on the population peaks of the flies (Salles, 1995; Ronchi-Tellesand, 2005).

In this way, the present work had as objective to evaluate the population fluctuation of fruit fly and the damage caused by insect in infestation of fruits in different genotypes of guava cultivated in organic system and also to study the possible correlations between this insect and meteorological factor.

**MATERIALS AND METHODS**

The experimental work was developed in APTA – Agência Paulista de Tecnologia dos Agronegócios, Regional Centre North Pole, in Pindorama-SP, 21° 13' South latitude and 48° 55 ' longitude West, 527 m altitude, with yearly average temperature of 22.8°C, annual average rainfall of 1,390.3 mm and average annual relative humidity of 71.6%. According to the Köppen classification, the climate is Aw type, defined as tropical humid, with rainy season in summer and dry in winter.

Used plants were from Germplasm Bank of guava, containing 85 genotypes that are 15 years old with three plants/genotype cultivated in the organic system of 6 × 5 m spacing. Through the analysis of soil, an application on surface of 1.5 ton/ha of dolomitic limestone in total area and 20 L of filter cake, around the trunk in each plant was carried out. The control of spontaneous plants was accomplished by cutter motor and manual weeding. In July, 2012, nine months before research, the plants suffered from drastic pruning and the main trunk presented a final height of 1.20 m from the ground.

For the study of population fluctuation of fruit flies in experimental field, yellow sticky traps were used (Bio Trap Biocontrol®), with 24.5 × 10 cm, spaced at about 50 m from each other in internal branches in the middle part of the plants and at a height of 1.5 m from the ground, totaling 20 traps. The assessments began in April, 2013, when the trees reached a uniform volume of cup and ended in April, 2014. The traps were kept in the field for 15 days and replaced by new, without interruption, being wrapped in plastic folders and taken to the laboratory for evaluation, where it was quantified and registered as fruit flies captured. For Anastrepha spp. the classification was carried out at the level of genus by difficulty in detaching the insect from the trap without damaging the structure, this is similar to the work of Calore et al. (2013) and Duarte et al. (2013).

Pearson correlations was used to calculate the data obtained among the fruit flies of the genus Anastrepha spp. and the meteorological factors such as minimum temperature (°C), maximum temperature (°C) and precipitation (mm) obtained during the period in which the traps were in the field. The correlation was not performed for the species C. capitata by the small number of individuals captured.

For evaluation of fruit flies fruits were collected at random, nine fruits not bagged by genotype at the stage of maturation and with the aid of a knife, the fruits were cut open looking for symptoms of insect attack (presence of larvae). Fruits with any degree of infestation were considered to be infested. The means were compared by Scott-Knott test at 5% probability. For statistics analysis the data were transformed in $\sqrt{X_i}$.  

**RESULTS AND DISCUSSION**

The fruit flies of the genus Anastrepha were prevalent in capturing performed through yellow sticky traps during
Table 1: Number of fruit fly captured in 20 yellow sticky traps installed in the orchard of guava, in different collections.

<table>
<thead>
<tr>
<th>Collecting</th>
<th>Insects captured</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Anastrepha spp.</td>
</tr>
<tr>
<td>01/04/2013</td>
<td>11</td>
</tr>
<tr>
<td>12/04/2013</td>
<td>14</td>
</tr>
<tr>
<td>02/05/2013</td>
<td>6</td>
</tr>
<tr>
<td>20/05/2013</td>
<td>16</td>
</tr>
<tr>
<td>03/06/2013</td>
<td>27</td>
</tr>
<tr>
<td>17/06/2013</td>
<td>27</td>
</tr>
<tr>
<td>01/07/2013</td>
<td>18</td>
</tr>
<tr>
<td>15/07/2013</td>
<td>22</td>
</tr>
<tr>
<td>29/07/2013</td>
<td>44</td>
</tr>
<tr>
<td>12/08/2013</td>
<td>19</td>
</tr>
<tr>
<td>26/08/2013</td>
<td>7</td>
</tr>
<tr>
<td>09/09/2013</td>
<td>6</td>
</tr>
<tr>
<td>30/09/2013</td>
<td>1</td>
</tr>
<tr>
<td>21/10/2013</td>
<td>3</td>
</tr>
<tr>
<td>04/11/2013</td>
<td>0</td>
</tr>
<tr>
<td>18/11/2013</td>
<td>0</td>
</tr>
<tr>
<td>09/12/2013</td>
<td>1</td>
</tr>
<tr>
<td>20/01/2014</td>
<td>4</td>
</tr>
<tr>
<td>03/02/2014</td>
<td>6</td>
</tr>
<tr>
<td>17/02/2014</td>
<td>8</td>
</tr>
<tr>
<td>03/03/2014</td>
<td>11</td>
</tr>
<tr>
<td>17/03/2014</td>
<td>93</td>
</tr>
<tr>
<td>31/03/2014</td>
<td>103</td>
</tr>
<tr>
<td>14/04/2014</td>
<td>75</td>
</tr>
<tr>
<td>Total</td>
<td>522</td>
</tr>
</tbody>
</table>

The sampling period. Some flies of the species *C. capitata* were also captured (Table 1).

The highest population densities of fruit fly of the genus *Anastrepha* spp. occurred in the second half of March, 2014 and the population peak of the insect occurred on the 23rd collection (March 31st), with a total of 103 flies, followed by the 22nd and 24th collections (17th March and 14th April), with a total of 93 and 75 flies, respectively, collected in 20 yellow sticky traps (Figure 1 and Table 1). It was noted that the highest incidence of fruit fly of the genus *Anastrepha* coincided with the time of fruiting of orchard, as should be expected (Calore et al., 2013).

Chiardia et al. (2004), studying the population fluctuation of fruit fly in citrus orchards in the region West of Santa Catarina – SC - Brazil, observed that the peaks of catching flies of the genus *Anastrepha* occurred from March to June. Santos et al. (1998) observed that the peak population of flies of the genus *Anastrepha* in orchard of guava in the city of Mossoró-RN-Brazil, occurred in June.

Aguilar and Zucchi (2003) studied the levels of infestation of the species of *Anastrepha* spp. in guava and found that the highest levels of infestation and population peaks occurred from May to July. The authors reported that in semi-arid regions, rainfall, coupled with hosts are the dominant factors in the population peaks and not only fruits. In this study, it was observed that, in the North Central region of the State of São Paulo, the population peak of tephritidae coincided with the time of fruiting of orchard and had no relationship with precipitation.

The smallest population densities of *Anastrepha* spp. occurred in the period from September, 2013 to February, 2014 (Figure 1), at the beginning of flowering until fruiting. These results corroborate Teles and Silva (2005) report stating that host fruit is the most important factor in determining the occurrence and population fluctuation of fruit flies and not abiotic factors.

The fruit flies of the genus *Anastrepha* resulted in a total of 522 individuals between males (207 individuals) and females (265 individuals) collected in 20 yellow sticky traps throughout the sampling period, being the genus of fruit flies that predominate. The total number of flies of the species *C. capitata* caught was only 18 individuals (Table 1). Although *C. capitata* attack guava (Zucchi, 2001), Raga et al. (2006) studied genotypes of guava to natural infestation by *Anastrepha* spp., in Monte Alegre do Sul-SP-Brazil, by obtaining puparia of tephritidae from fruit and...
Figure 1: Number of Anastrepha spp. captured in 20 yellow sticky traps, and occurrence of meteorological factors in orchard of guava, in April 2013 through April 2014.

Table 2. Simple linear correlation coefficient calculated between Anastrepha spp. and the meteorological factors minimum temperature (TMIN), maximum temperature (TMAX) and rainfall (PREC), in April, 2013 to 2014.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Linear correlation coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TMIN (°C)</td>
</tr>
<tr>
<td>Anastrepha spp.</td>
<td>0.1294</td>
</tr>
</tbody>
</table>

NS Non-significant.

not recovered adults of the species C. capitata during the evaluations. The authors reported that probably this fact was due to the low population densities of this species at the time of evaluation, where its population was equal or lower than 0.03 fly/trap/day using McPhail traps with hydrolyzed protein installed in the same experimental station.

Several researchers, in studies in Brazil, with population fluctuation of tephritids, also observed the predominance of fruit flies of the genus Anastrepha (Garcia and Corseuil, 1998; Uramoto et al., 2003). Aluja et al. (1996) assessing the population fluctuation of fruit fly in commercial orchards in southern Mexico suggested that this type of behavior is considered normal, since, although several species of tephritids are present in an orchard, just one or two species account for more than 90% of all fruit flies collected in traps.

The correlations between the meteorological factors and population fluctuation of fruit flies of the genus Anastrepha were not significant for all three parameters evaluated (Table 2). Calore et al. (2013) in a similar experiment reported that there have been no correlation with precipitation, but they observed significance to the minimum, average and maximum temperatures, indicating that the population growth of the insect is favored at higher temperatures.

Table 3 shows the percentage of fruits infested by larvae of fruit flies in nine fruits evaluated by access. By Scott-Knott testing, the accesses were divided into three groups, most with high infestations of 55.6 to 100% of fruits containing insect larvae. The access IAC-4-Cica deserves highlight because among the 50 accesses evaluated, it did not present any infested fruit, without differing from access Taquaritinga Comum (11.1%), both of red pulp. An important feature presented by these accesses is the fact that they presented early crop, an important fact to be taken into consideration since the area of the experiment was still with low occurrence of the insect.

The accesses Campos, L8P32B, Goiaba Polpa Amarela, Torrão de Ouro, Supreme BA, L2P4 and Supreme also had
few fruits attacked without any statistical difference observed (Table 3). It is worth remembering that the evaluations were performed with the ripe fruits, irrespective of maturation time. In organic farming, for the prohibition of agrochemical, the fruit is intended almost entirely to industry, given the difficulty of obtaining fruits without fruit fly larvae. The practice of bagging fruit is costly, demands a lot of labour and consequently increases production costs. However, it is still the only way to get healthy fruits for fresh consumption and export. As such working with materials that give resistance to insect attack is very important.

Raga et al. (2006) evaluated 11 accesses of guava at natural infestation by Anastrepha spp., in Monte Alegre do Sul-SP-Brazil, by obtaining puparia and verified that the L2P4 genotype showed the lowest rate of infestation of fruit flies in the experiment with averages of 2 to 5 puparia per fruit. The authors also reported that Indiana access showed the highest rate of infestation of the experiment, reaching 49 puparia in a single fruit. Similar data were obtained in the present experiment, where the L2P4 access also showed low infestation (33.3%, Table 3), indicating a material with a lot of potential resistance to fruit fly. Indiana access presented 77.8% of infested fruit, without significant difference from the accesses with 100% infestation. These results showed that the susceptibility and/or resistance of an access is itself associated and not to the weather or location, etc., since the behavior of the materials was similar in both study sites with different weather conditions.

### Conclusions

From the research work carried out the following conclusions are drawn:

- The fruit flies of the genus *Anastrepha* are found in...
greater quantity in guava trees, in the Central North of the State of São Paulo in Brazil. The highest population densities of fruit fly of the genus *Anastrepha* spp. occurs in the second half of March 2014, coinciding with the time of fruiting of orchard;  
- There is no correlation between the meteorological factors and population fluctuation of the fruit fly to the time of assessment;  
- Most of the fruits of the evaluated access features had high infestations by fruit fly;  
- Access "IAC – 4 – Cica" did not present fruit infested and "Taquaritinga comum" presents only 11.1% of infested fruit.

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