Faculdade de Agronomia
Eliseu Maciel
Fundada em 1883

Current Agricultural Science and Technology
ISSN 2317-2436
http://periodicos.ufpel.edu.br/ojs2/index.php/CAST

Potential population growth of *Melanaphis sacchari* (Zethner) reared on sugarcane and sweet sorghum

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Received: 24 February 2014 / Accepted: 05 June 2014 / Available online: 03 September 2014

ABSTRACT

The sugarcane aphid [*Melanaphis sacchari* (Zethner) (Hemiptera: Aphididae)]is a serious pest for sugarcane (*Saccharum officinarum*) and sorghum (*Sorghum* spp.). It causes damage by sucking the plant's sap and then transmitting *Sugarcane yellow leaf virus* (ScYLV).The aim of this work was to compare biological parameters, and trace the population growth of sugarcane aphid in its major host-plants: sweet sorghum and sugarcane. Newborn nymphs were reared on excised leaves in climatic chambers with controlled environmental conditions. The survival rate of offspring was recorded in order to obtain biological parameters derived from life tables. The parameters "reproductive period", "post-reproductive period", "fecundity" and "longevity" were significantly different by contrast and clearly showed that sweet sorghum is more suitable for the population growth of sugarcane aphids than sugarcane.

Keywords: Population; intrinsic rate of increase; life table; fecundity; ScYLV.

INTRODUCTION

The sugarcane aphid [*Melanaphis sacchari* (Zehtner)] is present in more than thirty countries and feeds on twenty species of graminaceous plants (Singh et al., 2004). In Brazil, this aphid mainly affects sugarcane (*Saccharum officinarum*), which is the major crop for biofuel production (Gonçalves, 2005). The main damage of the sugarcane aphid is to be a vector of *Sugarcane yellow leaf virus* (ScYLV), a virus responsible for great yield losses (Lopes et al., 1997; Gonçalves, 2005; Paray et al., 2011). For instance, losses measured in Louisiana (USA) are about 11-14% (Grisham et al., 2001).

Plant resistance is an important component in aphid management and can be favored by biological control. Sugarcane and sorghum resistance to *M. sacchari* is found, but it is not largely used as an option control of this pest. The plant resistance to *M. sacchari* is more extensively characterized in sorghum (Singh et al., 2004) than in sugarcane (Akbar et al., 2000). The most common resistance mechanism is antibiosis (Singh et al., 2004), but antixenosis has been found in sugarcane (Fartek et al., 2004) and a specific resistance gene in sorghum was also mapped (Wang et al., 2013).

When sugarcane and sorghum coexist in the field and even when they appear in crop succession, the resistance level is a critical factor for *M. sacchari* outbreaks. In Brazil the sweet sorghum (*Sorghum bicolor*) is an alternative crop used to provide matter for ethanol and sugar factories during the offseason of the sugarcane production (Teixeira et al., 1997).

Hypothetically, sweet sorghum could provide suitable habitat and food for a continuous population growth of sugarcane aphids in the field. If *M. sacchari* is able to perform well in sweet sorghum, the risk of outbreaks and the spreads of viruses could be high in the sugarcane-sweet sorghum systems. This work aims to investigate the potential population growth of sugarcane aphids on a sweet sorghum variety in comparison with the potential population growth on a sugarcane variety.

MATERIALS AND METHODS

One *M. sacchari* was obtained from sugarcane fields (undetermined variety), and an isofemale lineage was raised on sorghum (undetermined variety) planted in vases in the greenhouse. The bioassays were performed with newborn nymphs with four replicates (n_r=20 for each replicate, n_t=80 for each aphid/plant performance bioassay) considering each aphid as a repetition. Each nymph was placed on detached leaves of the sweet sorghum BRS506 variety and the sugarcane RB867515 variety. The leaves were partially dipped in small plastic pots with 3cm diameter and 5 cm height and filled with water. For bioassays, the leaves were standardized and came from the upper third part of the plant. Only the middle third of the leaves was used to assess aphid performance. The pots were put inside of transparent plastic pots of 12 cm diameter and 14 cm height. They were closed by a mesh fabric on the top. The pots with aphids were kept in a climatic chamber at 24°C ± 1°C with 70 % air humidity and 14 h photophase.

The reproduction time (in days) was classified in three periods - pre-reproductive, reproductive and post-reproductive. The pre-reproductive period was considered the time between the mother aphid's births until the production of its first nymph. The reproductive period was the time between the first and the last nymph produced. The post-reproductive period was the time after the last nymph produced and the death of the mother aphid. The fertility was the total amount of nymphs produced by a female during the reproductive period. The data of four replicates for each aphid performance bioassay were analyzed separately by contrast of aphid performance in the same host plant and between sugarcane and sorghum. In the case of absence of difference in the same plant group, all data of the replicates were grouped by plant species.

All biological parameters between two hosts were statistically compared using the Student *t*- test ($p \leq 0.05$).

Life tables with data of survivorship and reproduction were elaborated to obtain the net reproduction rate (R_0), the finite rate of increase (λ), the average time per generation (T), and the time for population duplication (DT).The intrinsic rate of increase (r_m) was calculated using the Wyatt & White (1977) formula. In all formulations it is given that:

$$R_0 = \Sigma l_x m_x, \qquad \text{Eq.(1)}$$

$$\lambda = e^{rm} \qquad \text{Eq. (2)}$$

$$T = \ln R_0 / r_m, \qquad \text{Eq. (3)}$$

$$DT = \ln 2/r_m \qquad \text{Eq. (4)}$$

$$r_m = 0{,}738 (\log_e M_d) / d \qquad \text{Eq. (5)}$$

where m_x is the age-specific number of female offspring; l_x, survivorship at age x; $m_x l_x$, number of nymphs produced by a female during the time interval; x, M_d, number of nymphs produced during the period d and d= pre-reproductive period.

RESULTS

There were no differences among aphid parameters among the same host bioassays. The exception was the longevity parameter, which was different only in the first bioassay of sorghum with the fourth bioassay of sugarcane (p =0.06), but there was no difference when the replicates were analyzed by group. However, the parameters were different in each combination of bioassay replicates between the two hosts plants tested.

On sweet sorghum, the lifespan varied between 8 and 42 days with 50 % survivorship at the 18th day. On sugarcane, the lifespan varied between 11 and 26 days, with 50% survivorship at the 15th day (Figure 1).

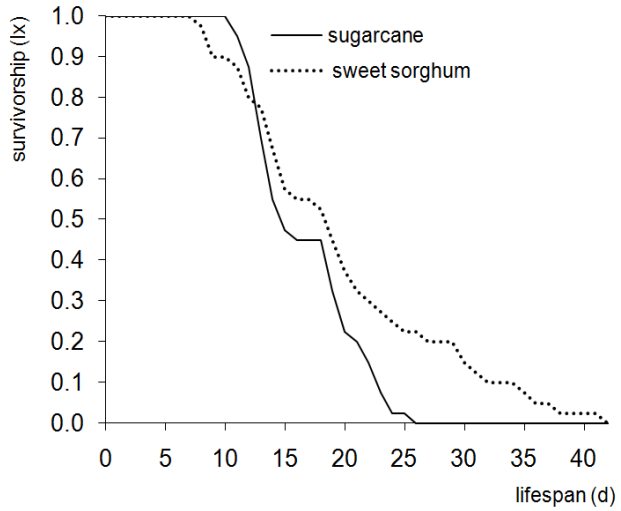

Figure 1. Daily survivorship of *Melanaphis sacchari* reared on two host-plantas: sugarcane (*Saccharum officinarum*) and sweet sorghum (*Sorghum bicolor*), 24°C ± 1°C with 70 % air humidity and 14 h photophase.

On sweet sorghum BRS506, the reproductive and post-reproductive periods were significantly longer than those on sugarcane (Table 1) and the aphid pre-reproductive period was not significantly different between the two hosts. The longevity and fertility were higher on sweet sorghum than on sugarcane (Table 1).The aphids reared on sweet sorghum had their lifespan increased by 18.3%. The number of offspring of aphids reared on sweet sorghum increased by 53.3 % in comparison with aphids reared on sugarcane.

The values for r_m, R_0, λ were higher on sweet sorghum than on sugarcane. The aphids' parameters on sugarcane, average time of a generation and time for population duplication, were higher than those on sweet sorghum (Table 1). The net reproduction rate of sugarcane aphids was higher by 50.4% than when they were reared on sweet sorghum.

Table 1. Biological parameters of *Melanaphis sacchari* reared on two host-plants: sugarcane (*Saccharum officinarum*) and sweet sorghum (*Sorghum bicolor*), 24°C ± 1°C with 70 % air humidity and 14 h photophase

	HOST		
Biological parameters	sweet sorghum BRS506	sugarcane RB867515	P
Pre-reproductive period(d)	9.1±0.60	9.3±0.50	0.400
Reproductive period(d)	11.10±1.20	6.70±0.70	0.001*
Post-Reproductive period(d)	5.10±0.50	3.80±0.20	0.006*
Fecundity(i)	25.60±3.80	16.70±2.30	0.030*
Longevity(i)	20.00±1.40	16.90±0.70	0.030*
R_o	27.70	18.40	
T	10.70	12.70	
Λ	1.36	1.26	
DT	2.30	3.00	
r_m	0.30	0.23	

* - estimate; Ro - reproduction rate; T- average time per generation; Λ- finite rate of increase; DT- the time for population duplication; r_m- the intrinsic rate of increase.

DISCUSSION

Plants that inhibit insect survival, growth or fecundity are classified as antibiosis-resistant (Painter, 1951). Antibiosis effects are observed by comparison. In the case of sugarcane, Akbar et al. (2010) found some sugarcane plants less aphid-susceptible using the measurement of reproductive parameters.

The aphids' pre-reproductive period is a parameter that can be affected by the host plant (Collins and Leather, 2001). Pre-reproductive time shortening could be an indication of host plant susceptibility (Tonet and Silva, 1994; Hesler, 2005), but it is not a general rule. The pre-reproductive period was not affected by resistant plant varieties compared to susceptible varieties (Fonseca et al., 2005). The pre-reproductive period is not a parameter to detect aphid resistance in the case of sugarcane aphids (Akbar et al., 2010). More clearly, the reproductive and post-reproductive periods are parameters that express plant resistance to an aphid (Tonet and Silva, 1994; Hesler, 2005; Fonseca et al., 2005). Our results corroborate with the findings obtained by those authors because the pre-reproductive period was not significantly different between aphids reared on sweet sorghum and aphids reared on sugarcane. Our findings are compatible with the existence of host suitability of the sugarcane variety tested in comparison with that of sweet sorghum.

Longevity and survivorship are other parameters that can be used to assess plant resistance by antibiosis (Hasan and Ansari, 2010). The plant that is most suitable as food for an insect is that which provides an increase in insect lifespan or the number of its offspring (Fonseca et al., 2005; Tonet and Silva, 1994; Hesler, 2005). According to our results, the sweet sorghum BRS506 tested is more suitable for healthy development of aphids than sugarcane RB867515.

A host effect on a specific biological trait does not provide enough evidence of host suitability for insect population growth. Sometimes, a compensation effect can occur, for example, when low fertility is compensated by a long lifespan or a short reproductive period is compensated by an increase in the number of progeny. Thus, a better assessment of host suitability can be obtained with the use of population growth parameters. The intrinsic rate of increase is one of the best parameters to assess insect performance among different host plants (Greenberg et al., 2001). However, slight differences in r_m may be difficult to interpret. In order to obtain r_m, other population parameters are obtained previously, and an assessment of all these parameters is enough to determine the plant's suitability for aphid population growth.

Here, all parameters indicated that the potential for the population growth of sugarcane aphids on sweet sorghum BRS506 is greater than that which was found for sugarcane RB867515. The population duplication time required for the sugarcane aphid was shorter on the sweet sorghum than that required for sugarcane. The value of R_o and λ clearly indicated that sweet sorghum BRS506 was a better host than sugarcane for the population growth of sugarcane aphids. Descamps and Chopa (2011) used life-table parameters to discriminate barley as the most suitable food for the bird-cherry oat aphid (*Rhopalosiphum padi*) among other six cereal species.

This study indicates that the sweet sorghum BRS506 variety enables the population growth of sugarcane aphids and it could magnify the infestation on sugarcane in field conditions. This information will be pivotal for managing sugarcane aphids and viruses spreading in sugarcane-sweet sorghum systems. However, we recommend more studies of sugarcane performance on different plant genotypes of sugarcane and sorghum in order to make an appraisal of host-resistance differences in these two hosts.

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