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RELATIONSHIP BETWEEN DAMAGE ON LEAVES CAUSED BY *Liriomyza huidobrensis* (DIPTERA, AGROMIZYDAE), ADULTS TRAPPED IN STICKY TRAPS AND PARASITOIDS IN A COMMERCIAL CROPS OF *Cucurbita maxima* VAR. *zapallito* (CUCURBITACEAE)

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ABSTRACT

Agromyzid leafminers cause damages in ornamental and horticultural crops. The objective of this study was to evaluate the number of adults of *L. huidobrensis* trapped in sticky traps in *C. maxima* var. *zapallito* and connect this with the total leaves, leaves damaged and parasitoids at different monitoring dates, and determine the correlation between the number of larvae and parasitoids, according to the number of galleries per leaf. Six traps were placed in a commercial plot, and they were replaced weekly. The total and damaged leaves were recorded weekly in 15 randomly picked plants. Damaged leaves were taken to laboratory where galleries per leaf were counted. Each leaf with a gallery was placed in a Petri dish until leafminer or parasitoid adults emerged. *Liriomyza huidobrensis* caused damage in in early crop stages. There was correspondence between adult population and damage and number of galleries per leaf with significant differences in the first monitoring date, which was not found with parasitoids.

Key words: leafminer, damage, parasitoids, summer squash.

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ABSTRACT

Relación entre el daño en hojas causado por *Liriomyza huidobrensis* (Diptera, Agromizydae), los adultos atrapados en trampas pegajosas y los parasitoides en un cultivo comercial de *Cucurbita maxima* var. *zapallito* (Cucurbitaceae).

Los agromícidos causan daños en cultivos ornamentales y hortícolas. El objetivo de este estudio fue evaluar el número de adultos de *L. huidobrensis* en trampas pegajosas ubicadas en un cultivo de *C. maxima* var. *zapallito*, y relacionarlo con el total de hojas, hojas dañadas y parasitoides en diferentes fechas de monitoreo, y determinar la correlación entre el número de larvas y de parasitoides, de acuerdo a la cantidad de galerías por hojas. Seis trampas pegajosas fueron colocadas en un lote comercial y reemplazadas semanalmente. En 15 plantas seleccionadas al azar se registró el número total de hojas y el de hojas dañadas. Las hojas dañadas fueron llevadas a laboratorio donde se contó el número de galerías por hoja, y cada una fue colocada en cajas de Petri hasta la emergencia de los adultos del minador o del parasitoide. La población de adultos estuvo en correspondencia con el número de galerías por hoja con diferencias significativas en la primera fecha de monitoreo, pero no con los parasitoides.

Palabras clave: minadores, daños, parasitoides, zapallito.

INTRODUCTION

Most agromyzid species exhibit a high level of host specificity restricted to a genus or family, while others are polyphagous (2). Thus, *Liriomyza* species cause damage during both larval and adult stages. Larvae excavate galleries in leaf parenchyma leaving the epidermis intact (27) on over 365 host plant species in 49 plant families, including ornamental, horticultural crops and weeds (30, 31). According to Foba *et al*. (2015) (4) *L. huidobrensis* (Blanchard) attacks 20 different crops, with differences in geographic distribution, host preferences and other biological characteristics (21, 27). In Argentina, it is one of the most polyphagous species, which attacks 9 wild species and 37 crops, and one of them is summer squash, *Cucurbita maxima* var. *zapallito* [(Carr.) Millan] (27). Adult females cause lesions with their ovipositor to feed on epidermis exudates (25). Damage decreases the photosynthesis capability, reduces nutrient assimilation, thus causing early leaves fall, and it also has the ability to transmit viruses and facilitate bacteria and fungi penetration (23, 5).

Many leafminers are controlled by parasitoids under natural conditions. However, in certain areas, they are a serious pest because natural control is disrupted by insecticide use (15, 16, 9, 20). The summer squash is a widespread crop in the area near the city of Santa Fe, and leafminer damage is very important. However, this pest has not been studied. The main objective of this study was to evaluate the number of adults of *L. huidobrensis* caught in sticky traps placed in a commercial plot of *C. maxima* var. *zapallito*, and the damage caused on total leaves. Also, the number of parasitoids was analyzed in relation to the number of galleries per leaf.

MATERIALS AND METHODS

***Study site*:** The study was carried out on "summer squash" crops (cv. Franco, Basso Seed Company, Argentina) in a commercial plot near the city of Santa Fe (31º32 'S; 60º40' O) in the province of Santa Fe, Argentina). The seeding date was July 15^{th}, 2014. The cultural practices were the usual ones for this crop, and only fungicides were applied in this plot –two sprays of sulfur and two of tebuconazole.

Sampling: The total number of leaves damaged by leafminers was recorded weekly in 15 plants randomly selected from 20 days after transplanting (to allow the pest to be installed) until harvest. The damaged leaves were collected and placed in Ziploc® plastic bags and taken to the Agricultural Zoological Laboratory, Facultad de Ciencias Agrarias (Universidad Nacional del Litoral), Santa Fe, Argentina. From each leaf, the number of galleries was counted, and each gallery (with a piece of leaf) was individually placed in a 5-cm-diameter Petri dish with wet cotton and filter paper on the bottom in order to maintain humidity. To capture adults, six 10x25-cm Süsbin® adhesive traps were placed in the crop plot at 50 cm from the ground, two on the north side and four inside the plot. The traps were replaced weekly and taken to laboratory, where the number of leafminer adults was counted using a 30x stereoscopic microscope.

Lab work: the leaves with galleries were taken to a climatic chamber (25 ± 5 ºC, 65 ± % RH, 14:10 L:D). The puparia were reviewed daily until adults of leafminers or endoparasitoids emerged, which were preserved in 1.5 ml Eppendorf® tubes with 70% ethanol until their identification, and labeled by date and plant number. Braconid parasitoids were identified following the key provided by van Achterberg and Salvo (1997) (1).

Data analysis: In order to measure the direct contribution of the independent variable (monitoring dates) and to explain the variability of dependent variables (number of larvae and parasitoids), a path analysis was performed. The correlations between damaged leaves, parasitoids and number of larvae according to number of galleries per leave were analyzed. Adults per sticky trap, total leaves, damaged leaves per plant, galleries per leaf, larvae and parasitoids (dependent variables) related to monitoring date (independent variable) were analyzed by ANOVA. Significant differences were determined by a Tukey test ($\alpha<0.01$). Results were analyzed with InfoStat (6).

RESULTS AND DISCUSSION

Adults collected in sticky traps had a maximum peak in the first sampling (27.8), which showed significant differences with the remaining collecting dates (Table 1). Then, they began to decline until the last week of September, when adults captured did not exceed 8 individuals. At the end of the crop cycle, the average was 2 adults per trap. The presence of adults is related to climate conditions. Larraín and Muñoz (1997) (10) indicated that the optimal temperatures for *L. huidobrensis* population range between 14 to 21ºC. These results coincide with the records of maximum temperature mean during the monitoring months (24.0, 28.3, 29.2 and 30.3 ºC, for September, October, November and December, respectively), i.e., it was inversely proportional to the number of adults trapped. Salas *et al.* (1992) (17) and Niño *et al.* (2009) (14) report that rainfall is the climatic factor that most negatively influences the pest population density. In our trial, rainfall was (in mm) 89.41, 66.79, 105.92 and 125.99, for the months mentioned above, respectively, and is possibly related with the number of adults trapped.

The adults captured in sticky traps and the average number of damaged leaves corresponded, 1.67 on the first monitoring date (Table 1) (9.64% of total leaves per plants), and 0.47, in the last observation (2.57% of total leaves per plant). These results could be due to the greater female pest crop colonization (11). Plants damaged early in the season, or with 25% or more of the leaves mined late in the season, will suffer significant loss of photosynthate production that extends the time required for crop completion (26).

The greatest damage was in lower leaves, which coincides with Mujica and Cisneros (2001) (12) and with López *et al.* (2010) (11). Our results showed an association between *L. huidobrensis* population and crop development, in line with López *et al.* (2010) (11) in potatoes, and Salvo and Val-

Table 1. L. huidobrensis *adults, total leaves and leaves damaged (number per plant) (Mean ± SD) by monitoring date.*
Tabla 1. Nº de adultos de L. huidobrensis*, Nº de hojas totales, número de hojas dañadas (número por planta (Media ± DS) por fecha de monitoreo.*

Dates	Nº adults/trap[1]	Nº leaves/plant[1]	Nº of damaged leaves/plant[1]
09-Set	27.8 ± 17.19 a	17.3 ± 4.22 c	1.7 ± 1.40 ab
16-Set	18.2 ± 10.28 ab	14.6 ± 2.82 c	1.5 ± 1.51 ab
23-Set	15.2 ± 15.85 ab	19.4 ± 3.42 bc	2.8 ± 1.97 a
07-Nov	3.2 ± 2.23 b	28.0 ± 7.59 a	1.8 ± 2.18 ab
14-Nov	3.7 ± 4.76 b	28.3 ± 7.01 a	0.4 ± 0.74 b
21-Nov	7.7 ± 3.33 ab	24.8 ± 6.49 ab	0.5± 0.83 b
06-Nov	5.4 ± 3.19 b	26.3 ±3.83 a	1.1 ± 0.35 b
11-Nov	2.0 ± 1.41 b	18.7 ± 1.45 bc	0.5 ± 1.06 b

[1]*Mean values within a column followed by the same letter are not significantly different, according to Tukey test (α=<0.01).*

[1]*Valores medios en una columna seguidos por la misma letra no son significativamente diferentes. Test de Tukey (α=<0.01).*

ladares (1995) (18) in beans, for the same species. Population density remains high during early crop stages, and declines during crop senescence (29).

The number of galleries per leaf are related to the number of adults captured in sticky traps (Table 1 and 2), with significant differences, coincident with seedling crops to flowering beginnings. On 16th September the highest average was recorded (5.62 ± 4.69), possibly due to the lag between the adults captured in traps and larvae inside the leaves (Table 2), and because *L. huidobrensis* distribution was available throughout the season (22). The number of galleries declined at the end of the crop cycle, with significant differences on 14th and 21th October (0.06 ± 0.24) (13, 11) because females appear to be able to select those plants that provide a higher performance for their offsprings (28).

In our study the parasitoids were only found on three sampling dates (Table 2). The parasitoid species was *Phaedrotoma scabriventris* (Nixon) (=*Opius scabriventris*) (Hymenoptera, Braconidae), a solitary, koinobiont, and larva-pupal endoparasitoid. Females lay their eggs directly inside the second-third stage of larval bodies and the larvae develop inside. The parasitized leafminer larvae still consume the tissue of plant leaves until their pupation (13). The

Table 2. Galleries, L. huidobrensis *larvae and parasitoids (number per leaf) in* C. maxima *var.* zapallito *(Mean ± SD) according to monitoring dates.*
Tabla 2. Número de galerías, de larvas de L. huidobrensis *y de parasitoides, por hoja, en* C. maxima *var.* zapallito *(Media ± DS) por fecha de monitoreo.*

Dates	n*	Nº galleries/leaf[1]	Nº larvae/leaf[1]	Nº parasitoids/leaf[1]
09-Set	28	4.5 ± 3.72 ab	0.5 ± 0.96 a	0 b
16-Set	26	5.6 ± 4.69 a	0.2± 0.49 a	0.5 ± 0.02 b
23-Set.	44	4.7 ±3.80 ab	0.2 ± 0.61 a	0.2 ± 0.45 ab
07-Oct.	32	2.7 ± 3.01 abc	0.2 ± 0.55 a	0.1 ± 0.34 ab
14-Oct	17	0.1 ± 0.24 c	0.1± 0.24 a	0 b
21-Oct.	17	0.1 ± 0.24 c	0.1 ± 0.24 a	0 b
06-Nov	15	0.1 ± 0.35 c	0 a	0 b
11-Nov	15	0.5 ± 1.13 bc	0 a	0 b

*[1]Mean values within a column followed by the same letter are not significantly different. Tukey test (α=<0.01). *n= Total leaves per plant.*

*[1]Valores medios en una columna seguidos por la misma letra no son significativamente diferentes. Test de Tukey (α=<0.01). *n= Nº total de hojas por planta.*

highest parasitized larvae percentage was recorded on 23rd September (72.0%), followed by 7th October (59.0%). According to Videla *et al*. (2006) (28) higher mortality rates by *P. scabriventris* were found on those crops where the leafminer was larger. Different authors found variable parasitoidism percentages according to natural enemy species, host and crop (3). Salvo and Valladares (1995) (18) found 51.6% of *L. huidobrensis* larvae attacked by *P. scabriventris* in beans, whereas Cure and Cantor (2003) (4) mentioned that, after blooming, parasitoidism by *Diglyphus begini* (Ashmead) (Hymenoptera, Eulophidae), reached 90.0% in *Gypsophila paniculata* L. (Caryophyllaceae), and decreased (70.0%) at the crop cycle end, without insecticides to control pest. In our study, parasitoid population was not abundant, probably because the host larvae were not large enough to allow parasitoid reproduction.

The path analysis showed a significant correlation between the number of parasitoid and leafminer larvae, as a function of the number of galleries per leaf (Fig. 1 a, b). For parasitoids (r=0.30; P<0.001) the analysis indicates a little relation to leave galleries, while for larvae (r=0.59; P<0.001), although low, the value indicates a better fit. Parasitoids did not exercise a dense-dependent control on *L. huidobrensis*, unlike the results found by Ehler (1992) (7), and Salvo and Valladares (1995) (18).

The regional biodiversity clearly provides a rich community of indigenous parasitoids that contribute to the control of the native *Liriomyza* species, despite the difficulties in quantifying the effects of indigenous parasitoids (often due to patterns of pesticide use), and they should be treated as a resource and protect them as much as possible (24). Therefore, it is necessary to continue studies especially referring to biology,

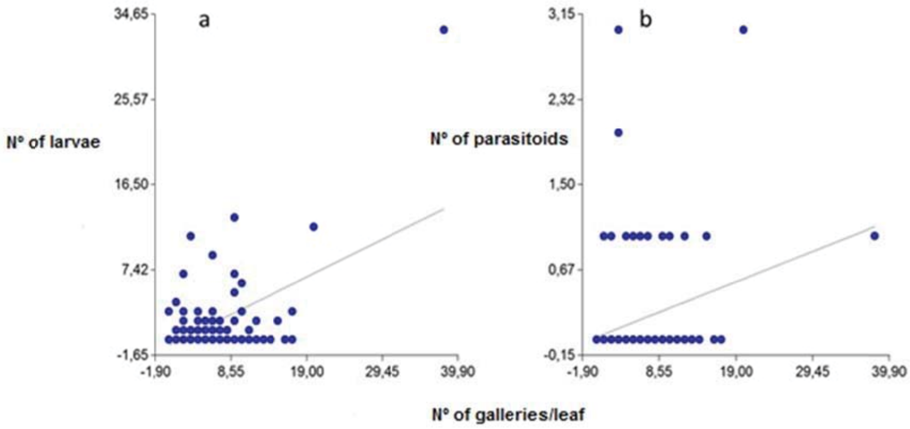

Figure 1. Correlation between number oof L. huidobrensis *larvae (a) and parasitoids* (P. scabriventris) *(b), according to the number of galleries per leaf in* C. maxima *var.* zapallito.

Figura 1. Correlación entre el número de larvas de L. huidobrensis *(a) y de parasitoides* (P. scabriventris) *(b), de acuerdo al número de galerías por hoja en* C. maxima *var.* zapallito.

natural mortality factors, alternative hosts, monitoring, among others, which will allow for achieving a rational management of *Liriomyza* sp. in horticultural crops in the province of Santa Fe, Argentina.

CONCLUSIONS

Liriomyza huidobrensis causes damage in commercial plots of summer squashes in early stages of development, near the city of Santa Fe, Argentina, with 25% or more of the leaves mined. Adults collected in sticky traps had a maximum peak in the first sampling (27.8) with significant differences with the remaining collecting dates. On 16th September the highest average number of galleries (5.62 ± 4.69) was recorded, which declined at the end of the crop cycle. Adult population showed correspondence with damage and number of galleries per leaf, with significant differences in the first monitoring date. The relation between *Phaedrotoma scabriventris* and leave galleries was low, but the relation value for larvae indicates a better fit, both there of which are not significant.

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DISCLOSURE

The authors report no conflicts of interest in this study.

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