Management of *Neoleucinodes elegantalis* (Lepidoptera: Crambidae) in Tomatoes Using Mating Disruption and Attract and Kill

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**ABSTRACT**

The mating disruption technique has been widely used for the control of several lepidopteran pests. In the present study, we assessed the efficiency of two formulations of SPLAT Neo, a wax emulsion containing E-11-hexadecenol, with and without the insecticide cypermethrin, in affecting mating disruption of *Neoleucinodes elegantalis* (Guenée). We also determined the best phenological age or stage of the crop for the application of the pheromone formulation, based on its effectiveness in reducing injuries on tomato fruits. We performed two field trials. The first field trial had three treatments: (1) Areas treated once (30 days after transplanting seedlings) with SPLAT Neo (mating disruption, formulation without cypermethrin); (2) Areas treated once with SPLAT Cida Neo (attract and kill, formulation with cypermethrin), and (3) Control plots, i.e. areas treated with the growers’ pest management procedures, based on pre-scheduled calendar applications of conventional insecticides. The use of SPLAT Neo with and without cypermethrin resulted in a significant season-long reduction of the average number of *N. elegantalis* eggs throughout the tomato cycle, compared to the control. Areas that received two SPLAT Neo applications had a lower number of males captured by monitoring pheromone traps, a lower number of eggs laid in the field, and significantly lower levels of fruit injury at pre, first, and second tomato harvests. The crop subjected to a single SPLAT Neo application, however, experienced reduction in fruit injury only at the second harvest. Our data suggest that two SPLAT Neo applications promote efficient control of *N. elegantalis*, resulting in significant reduction of fruit damage in tomato.

**Keywords:** Behavioral control, Pheromone release technology, Sexual pheromone, SPLAT, Tomato phenology.

**INTRODUCTION**

The small tomato borer, *Neoleucinodes elegantalis* (Guenée) (Lepidoptera: Crambidae), is considered a key pest of tomato, severely infesting the fruit, rendering them unsuitable for consumption and industrial processing (Gravena and Benvenga, 2003). It occurs in virtually all staked and crawling tomato producing regions in Brazil, having as host plants all the solanaceous fruits such as brinjal, jilo, joa, jurubeba and pepper (Zucchi *et al*., 1993). Its control has been carried out almost exclusively with the use of synthetic insecticides (Reis and Souza, 1996), which are most often applied in an indiscriminate way, without any regard to the principles of ecological pest management. Furthermore, chemical control has limited effectiveness, mainly due to the habit of the pest, whose neonate larvae promptly penetrate into the fruit, protecting themselves from insecticides and natural enemies (Eiras and Blackmer, 2003). Thus, the use of other

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control tactics that optimize the management of this pest has been broadly required.

The mating disruption technique has been widely used for the control of lepidopteran pests in recent decades. Its success was observed in the control of the oriental fruit moth, Grapholita molesta Busck, in apples and peaches (Stelinski et al., 2007; Pastori et al., 2008; Härter et al., 2010), of the codling moth, Cydia pomonella (L.) (Stelinski et al., 2007; Stelinski et al., 2009; Knight et al., 2012) and of the citrus leafminer, Phyllocnistis citrella Stainton (Stelinski et al., 2010). This method consists of distributing a large amount of synthetic sex pheromone in the field, aiming to prevent the male from finding a female, disrupting mating and, consequently, preventing the emergence of new generations of the pest in the treated area (Cardé and Minks, 1995; Witzgall et al., 2008).

The use of sex pheromones in pest control has several advantages over conventional chemical control, including the absence of toxicity to humans and other vertebrates, and high specificity to the target pest species. Furthermore, sex pheromones lead to behavioral responses in target insect pests within a few minutes. Another advantage, in contrast to the use of insecticides, is that the effectiveness of mating disruption increases over sequential use over the years, resulting in increased reduction of pest density (Witzgall et al., 2008; Stelinski et al., 2009). This technique, when used with long-lasting flowable formulations like SPLAT, also presents the possibility of mechanical application through adapted spray equipment, which may perform the application in two rows of grape vines simultaneously, optimizing its use (Teixeira et al., 2010).

Thus, the objectives of this study were to evaluate the efficiency of a component of N. elegantalis sex pheromone formulated in SPLAT in promoting mating disruption, the best suitable phenological age in tomatoes for the application of the disruption formulation, and the level of N. elegantalis mating disruption efficiency and related prevention of fruit injuries.

MATERIALS AND METHODS

Formulation Used

The SPLAT® formulation (Specialized Pheromone Technology and Lure Application) was developed and patented by ISCA Technologies (Riverside, California, USA), consisting of an amorphous and pasty emulsion composed of wax, oil, and water, which controls the release of semiochemicals and insecticides. The formulations contain an identified component of the N. elegantalis sex pheromone, with or without insecticide.

SPLAT Treatment

SPLAT treatment was carried out in commercial crawling tomato crops, variety TY, spaced 0.6×3 m, in the town of Bezerros (2011) (08° 09’14, 1” S; 35° 43’29, 2” W and 462.9 m asl). An area of 3 ha was used, divided into three sub-areas containing the following treatments: (a) SPLAT Cida Neo- (SPLAT Neo with Cypermethrin+grower’s treatments); (b) SPLAT Neo+ grower’s treatments, and (c) Control (grower’s treatment), which was based on insecticide applications at pre-established schedules. Treatment plots were spaced 50 m from the control plot, isolated by a barrier of native vegetation (Savanna hyperxerophilic), believed to aid in the prevention of the invasion of gravid N. elegantalis females. There was a distance of 40 m between treatments. SPLAT Neo formulations were applied manually with the aid of a manual SPLAT applicator 30 days after transplanting, i.e. during first tomato bunches. The application was performed at 3,000 point sources ha⁻¹ of SPLAT Cida Neo or SPLAT Neo, which resulted in one in every three plants receiving a point source. At the edges of the treatments (approximately 10 m) were applied 10% more point sources, aiming to reduce possible edge effects, common in this type
of experiment (Mafra-Neto, 2005). Each point source applied to the plants contained 
~1 g of the product applied at the pointer of the branches near the inflorescence. Egg 
counts were carried out weekly on tomato bunches, with fruit size of approximately 2 

cm in diameter. According to Blackmer et al. (2001), under field conditions, 
N. elegantalis lays 89% of the eggs on small tomato fruits of about 2.3 cm diameter. For 
the egg count, eight sites per treatment (four sites at the edge and four at the center of the 
plot) were evaluated. Each point of 
evaluation was composed of five sequential 
plants, which were duly marked with 
ribbons and cards. In each plant, a bunch 
with five fruits was evaluated, totaling 25 
fruits examined per plot. The eggs were 
collected with the aid of a fine-tipped brush 
dipped in water, and transferred to a Petri 
dish containing moist filter paper. The Petri 
dishes were sealed with plastic film and 
packed in plastic boxes, which were taken to 
the Laboratory of Agricultural Entomology, 
UFRPE, where the eggs were quantified 
with the aid of a stereoscopic microscope.

To verify the injuries caused by N. elegantalis, the harvest of damaged and 
undamaged fruits was performed in six rows 
of 50 m of length per treatment, which were 
distributed three rows at the center and three 
at the edges, totaling 300 linear meters per 
treatment.

**Monitoring N. elegantalis**

The monitoring of N. elegantalis population dynamics was conducted in a 
commercial crop with 3 ha of crawling tomato, variety TY, in the town of Camocim 
de São Félix, PE, during the crop cycle, in 2011. Four delta traps baited with a septa 
containing the sex pheromone BIO NEO® (Biocontrol, Pest Control Methods Ltda., 
São Paulo) were installed per hectare. Traps 
were properly identified and distributed two 
at the center and two at the edges, fixed on 
wooden stakes 1.5 m in height, always 15-30 
cm above the plant canopy and with the 
trap’s openings facing the direction from 
which the wind was coming.

**Double SPLAT Treatment**

This was carried out in a commercial field 
with 3 ha of crawling tomato, variety TY, in 
the town of Camocim de São Félix, PE, 
from November 2011 to February 2012. Each treatment occupied an area of 1 ha 
spaced 50 m from each other. The treatments including tomato cultivar, 
product application, density of point sources 
and the methodology used were similar to 
those of experiment 1; however, SPLAT 
formulations were applied twice, the first 
application at 20 days after transplanting 
(early flowering) and the second at 30 days 
(with the first bunches of fruit). To evaluate 
the level of disruption of male orientation 
to pheromone sources, we used four plastic 
delta traps (28×20×15 cm) (ISCA 
Tecnologias, Ltda, Ijui, RS) lured with 
rubber septa impregnated with the synthetic 
sex pheromone of the pest per treatment, 25 
m apart from each other. The septa were 
replaced every 45 days and the floor 
containing adhesive glue was replaced as 
needed. Trap catches were tabulated weekly. 
Methodology of egg count and 
quantification of fruit injury was as 
described in Field Trial 1.

**Statistical Analysis**

We used a completely randomized design 
consisting of three treatments, each divided 
into eight sampling units. The number of 
eggs collected was analyzed by multivariate 
repeated measures over time (P< 0.05) 
(PROC ANOVA specifying PROFILE) 
(SAS Institute, 2001). The sampling dates 
(7, 14, 21, 28, 35, 42, and 49 days after 
treatment) were considered repeated 
measures in this analysis, as eggs were 
sampled several times and on the same 
plants in the same area (Green, 1993; Paine, 
1996), thus, avoiding the problem of
"pseudo-replication" over time (Stewart-Oaten et al., 1986; Green, 1993). The number of eggs and adults collected weekly and of fruits with injuries was subjected to analysis of variance. For number of eggs and males collected, analysis of variance was done after a square-root (x+0.5) transformation of the data. Means were compared by Tukey test, 5% probability, using SAS version 8.02 (PROC GLM SAS Institute, 2001).

RESULTS

SPLAT Treatment

The number of *N. elegantalis* eggs was high in all the treatments during the first evaluation, seven days after treatment. SPLAT Cida Neo caused significant reduction in oviposition ($F= 6.09$, $P= 0.008$) compared to the control (Figure 1) (HSD Tukey at 5% significance). This effect was not observed for SPLAT Neo in the first evaluation. From the following evaluation onwards, both SPLAT treatments showed significant reductions in oviposition, compared to the control ($F= 15:46$, $P< 0.0001$) (Figure 2). There was, however, a directly proportional relationship between the number of eggs and the days after SPLAT application, from 14 days after product application (Figure 1).

Repeated measure analysis over time allowed the time effect and its interactions in treatments to be interpreted. All interactions between treatments (SPLAT Cida Neo and SPLAT Neo) and time (days after SPLAT treatment) were significant ($F= 2.37$, $P= 0.02$) in reducing the number of *N. elegantalis* eggs. Also, there was a significant effect of time (days after SPLAT treatment) ($F= 37.25$, $P<0.0001$) and treatment ($F= 14.45$, $P= 0.0004$).

Fruit crop injury caused by *N. elegantalis* in field trial 1 did not differ among treatments in the first harvest. At the second harvest, there was no significant difference between SPLAT treatments, but both SPLAT treatments significantly reduced fruit injuries when compared with the control (Table 1).

Monitoring *N. elegantalis*

The presence of *N. elegantalis* in pheromone baited traps was observed since

![Figure 1. Number of *Neoleucinodes elegantalis* eggs during the development of crawling tomato, variety TY, submitted to emulsified wax (SPLAT Cida Neo and SPLAT Neo), carried out 30 days after transplanting or conventional control (Bezerros, PE, 2011).](image-url)
the onset of fruiting. There was an increase in the number of males caught in monitoring traps, starting when the plants started growing the third tomato bunches, 46 days after transplantation. The number of captured males gradually increased until it reached a peak at 78 and 86 days (Figure 3).

**Double SPLAT Treatment**

Both SPLAT treatments caused complete pheromone trap shutdown in the first evaluation at 7 days after treatment, whereas the control monitoring traps captured 4.75 males per trap (Figure 4). At the first evaluation, 7 days after treatment, no eggs were observed in any of the treatments (Figure 5).

A significantly lower number of *N. elegantalis* males were captured in areas treated with SPLAT Cida Neo and SPLAT Neo than in the conventional control areas throughout the evaluation period (49 days) (F= 38.05, P< 0.0001). Trap captures in the SPLAT Cida Neo treatment showed a population peak in the third and last evaluations, carried out at 41 and 69 days after transplanting (21 and 49 days after the first treatment) (Figure 4). In general, the average number of collected males was 8.17 insects per trap per day in the control, 1.32 in SPLAT Cida Neo, and 0.79 in SPLAT Neo, confirming that the pheromone was effective in disrupting *N. elegantalis* male orientation, as the capture was reduced by 83.84% in SPLAT Cida Neo and 90.45% in SPLAT Neo.

Repeated measure analysis over time allowed the time effect and its interactions in treatments to be interpreted. All interactions between treatments (SPLAT) and time (days after SPLAT treatments) were significant (F= 12.67, P< 0.0001) in reducing the number of *N. elegantalis* eggs. Also, there was a significant effect of time (F= 11.18, P< 0.0001) and treatment (F= 53.71, P< 0.0001) (Table 1).

The use of SPLAT significantly reduced the egg collection when compared to the control, except at the first evaluation (7 days after the first treatment), in which the SPLAT Cida Neo caused no significant reduction in the number of eggs (F= 2.79, P = 0.08).

It was also observed that the number of eggs in the SPLAT Cida Neo treatment was higher than that of the SPLAT Neo throughout all the evaluations (Figure 5) (Tukey’s test, P< 0.05), although the mean number of eggs was significantly lower in both treatments compared to the control (Figure 2, Table 1).
Table 1. Percentage of damaged and undamaged fruits (means±SE) by *Neoleucinodes elegantalis* in the 1\textsuperscript{st} and 2\textsuperscript{nd} harvests in tomato crops treated either with SPLAT Cida Neo, SPLAT Neo, or conventional control.\textsuperscript{a}

<table>
<thead>
<tr>
<th>Treatments</th>
<th>1\textsuperscript{st} Harvest</th>
<th>Damaged fruits±SE (%)</th>
<th>2\textsuperscript{nd} Harvest</th>
<th>Damaged fruits±SE (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>34.34 ± 1.01\textsuperscript{a}</td>
<td>65.66 ± 1.01\textsuperscript{a}</td>
<td>59.44 ± 0.56\textsuperscript{b}</td>
<td>40.55 ± 0.56\textsuperscript{a}</td>
</tr>
<tr>
<td>SPLAT Cida Neo</td>
<td>32.64 ± 0.69\textsuperscript{a}</td>
<td>67.36 ± 0.69\textsuperscript{a}</td>
<td>81.13 ± 4.18\textsuperscript{a}</td>
<td>18.67 ± 4.28\textsuperscript{b}</td>
</tr>
<tr>
<td>SPLAT Neo</td>
<td>40.21 ± 3.47\textsuperscript{a}</td>
<td>59.79 ± 3.47\textsuperscript{a}</td>
<td>81.31 ± 1.38\textsuperscript{a}</td>
<td>19.39 ± 1.04\textsuperscript{b}</td>
</tr>
</tbody>
</table>

Causes of variation

<table>
<thead>
<tr>
<th>Causes of variation</th>
<th>DF</th>
<th>F</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Among treatments</td>
<td>2</td>
<td>14.45</td>
<td>0.0004</td>
</tr>
<tr>
<td>Time</td>
<td>4</td>
<td>37.25</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Time×Treatment</td>
<td>8</td>
<td>2.37</td>
<td>0.02</td>
</tr>
</tbody>
</table>

Wilks’ Lambda value= 0.029

Double application (20 and 30 after transplanting)

<table>
<thead>
<tr>
<th>Treatments</th>
<th>1\textsuperscript{st} Harvest</th>
<th>Damaged fruits±SE (%)</th>
<th>2\textsuperscript{nd} Harvest</th>
<th>Damaged fruits±SE (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>40.28 ± 6.53\textsuperscript{b}</td>
<td>59.75 ± 6.52\textsuperscript{a}</td>
<td>73.17 ± 3.17\textsuperscript{b}</td>
<td>26.82 ± 3.17\textsuperscript{a}</td>
</tr>
<tr>
<td>SPLAT Cida Neo</td>
<td>67.94 ± 6.62\textsuperscript{a}</td>
<td>32.06 ± 6.62\textsuperscript{b}</td>
<td>86.74 ± 3.27\textsuperscript{a}</td>
<td>13.26 ± 3.27\textsuperscript{b}</td>
</tr>
<tr>
<td>SPLAT Neo</td>
<td>67.68 ± 2.67\textsuperscript{a}</td>
<td>32.32 ± 2.67\textsuperscript{b}</td>
<td>91.90 ± 1.77\textsuperscript{a}</td>
<td>8.10 ± 1.89\textsuperscript{b}</td>
</tr>
</tbody>
</table>

Causes of variation

<table>
<thead>
<tr>
<th>Causes of variation</th>
<th>DF</th>
<th>F</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Among treatments</td>
<td>2</td>
<td>53.71</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Time</td>
<td>5</td>
<td>11.18</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Time×Treatment</td>
<td>10</td>
<td>12.67</td>
<td>&lt; 0.0001</td>
</tr>
</tbody>
</table>

Wilks’ Lambda value= 0.14

\textsuperscript{a} The same letters in the same column, for the harvests, do not differ significantly by Tukey test at 5\% probability.

Figure 3. Population fluctuation of *Neoleucinodes elegantalis*. Number of males captured per week in delta traps baited with the pheromone BioNeo\textsuperscript{b} in crawling tomato crops, variety TY (Camocim de São Félix, PE, 2011).
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Figure 4. Average number of Neoleucinodes elegantalis males collected in delta traps on tomato, variety TY, submitted to emulsified wax (SPLAT Cida Neo and SPLAT Neo), 20 and 30 days after transplanting and treated with conventional control (grower’s pest management program) (Camocim de São Félix, PE, 2011 - 2012).

Figure 5. Average number of Neoleucinodes elegantalis eggs during the development of crawling tomato, variety TY, exposed to emulsified wax (SPLAT Cida Neo and SPLAT Neo), 20 and 30 days after transplanting (Camocim de São Félix, PE, 2011 - 2012).

number of eggs had been significantly reduced in both treatments (Figure 6).

At the first harvest, a significant reduction in injuries on the fruits was observed, which reached 32.06% (±6.62) and 32.32% (±2.67) in the treatments submitted to SPLAT Cida Neo and SPLAT Neo, respectively, compared to the control. In the second harvest, the reductions in injuries were 65.66% (±1.01) and 67.36% (±0.69), in the treatments submitted to SPLAT Cida Neo and SPLAT Neo, respectively, corresponding to three times less damaged fruit than the control (Table 1).
DISCUSSION

The density of pheromone point sources per area is an important factor for the efficiency of male mating disruption, as it will influence the mechanisms involved in this process. Thus, in the present work, the high population density and the behavioral peculiarities of *N. elegantalis* led to the decision to apply a high dispenser density (3000 sites/ha). Several mechanisms can explain communicational disruption, including false-plume-following, camouflage, nervous system desensitization including adaptation and habituation, sensory imbalance, and combinations thereof (Miller et al., 2006). However, our field data did not elucidate which mechanism might be responsible for mating disruption in *N. elegantalis*.

In general, it was found that the higher the number of dispensers, the lower the number of males captured in traps and, therefore, the greater the efficiency of the mating disruption program (Bohnenblust et al., 2011). Härter et al. (2010) achieved an efficient control of *G. molesta* in peach, using 1,000 pheromone point sources ha<sup>-1</sup> (SPLAT® emitters), reducing the males captured in traps and the damage caused by this pest. Pastori et al. (2008) tested 1000 release sites (SPLAT® emitters) of the *Bonagota salubricola* Meyrick pheromone, associated with the *G. molesta* pheromone in apple orchards. This treatment reduced the male captures of both species only in the first season, as the reduction in the following cycle was only observed for *G. molesta*. Still, this reduction in male capture, in this case, was not reflected in a reduction in the damage caused by the pest. The same happened with the millet stem borer, *Coniesta ignefusalis* Hampson, according to Youm et al. (2012). They achieved a 99% suppression in capture of male millet stem borer in pheromone monitoring traps with the application of 400 polyethylene vials loaded with 0.5 mg pheromone/ha replaced every 21 days in 0.5 ha plots. However, the sampling of the central portions of these plots before and after harvest showed no significant differences in infestation, damage, or yield loss between plots treated with pheromone and untreated plots. This was possibly due to a large border effect in

![Figure 6](image_url)

**Figure 6.** Average number of *Neoleucinodes elegantalis* eggs during the development of crawling tomato, variety TY, exposed to emulsified wax (SPLAT Cida Neo and SPLAT Neo), and control (producer’s technology), 20 and 30 days after transplanting (Camocim de São Félix, PE, 2011-2012). Columns with different letters present significant difference by Tukey test (P< 0.05).
these small plots, fostering the oviposition by gravid females in most of the plot area.

The data seem to support the hypothesis that suppressing mating early on, at first flowering stage, might be important to effectively suppress *N. elegantalis* in tomato fields. But the density of release points, the pheromone dosage, or both, may also play an important role in pest suppression. Thus, further bioassays should be conducted to study the effect of the timing of SPLAT Neo application, point source density, pheromone dose and their interaction in order to achieve a highly effective suppression of *N. elegantalis* in commercial tomato fields. In Michigan, it was shown that a single mechanical application of SPLAT-OFM very early in the season not only achieved nearly complete trap shutdown all the way to harvest, but it also completely disrupted mating, measured with tethered *G. molesta* virgin females in treated apple orchards (Stelinski et al., 2007).

Another aspect to be considered is the fact that the pheromone release rate by some prototype SPLAT formulations falls exponentially over time (Stelinski et al., 2007, Stelinski et al., 2009, Knight et al., 2012). A reduction in the emission rate of *N. elegantalis* sex pheromone by the SPLAT Neo formulations as they aged in the field could explain the observed increase in the number of eggs throughout the evaluations over time in our trials. Fernández and Salas (1985) reported that the *N. elegantalis* development period from egg to adult was ~30 days and the pre-oviposition period was 3.84 days, in a study conducted in tomato fruits. The observed increase in *N. elegantalis* infestation at 78 days after transplanting could be a consequence of the development and egg-laying of the untreated first *N. elegantalis* generation to invade the crop.

Another possibility that can be considered is the occurrence of mated female immigration from outside the treated area. According to Cardé and Minks (1995), the immigration ability, aiming at the entry capacity of mated females coming from outside the treated area, can be a big problem for this technique that only prevents mating. Although the high levels of mating disruption in the area under the sex-pheromone influence result in extremely low levels of mating in the local pest population, they do not protect the area from the immigration of gravid females from outside populations. The effect of the immigration of gravid females is higher along the edges of the field, and the size of the edge correlated with the ability of the species to disperse. When gravid females are abundant and highly mobile, the edge effect is high, and edges where oviposition and larval damage is observed can be extensive. In cases of large edge effect, mating disruption will likely fail when there is no strong geographic isolation (geographic barriers) between populations; for example, if used in small plots by a producer in an area that is not isolated from other commercial tomato fields. Witzgall et al. (2008) observed that programs in larger areas of 100 or more hectares of treated orchards seemed to lead to effective mating disruption programs due to the reduced effect of gravid female migration. Still, besides the small treated areas, our results in this study indicate that mating disruption of *N. elegantalis* was successfully achieved with SPLAT Neo, because the levels of fruit injury were generally lower in mating disruption and attract and kill treatments, compared with the tomato plots treated only with conventional synthetic insecticides. This indicates that mating disruption using SPLAT Neo, with or without the addition of insecticide in the formulation, was effective in the management of *N. elegantalis*. This type of dispenser reduced by half the damage caused by *G. molesta* in apple orchards (Stelinski et al., 2007) and the use of the mating disruption method in this culture has led to a reduction in damage caused by *C. pomonella* and *G. molesta* (Bohnenblust et al., 2011; Knight et al., 2012).

In this work, we also tested SPLAT Cida Neo, i.e. SPLAT formulations containing
pheromone and small doses of the insecticide cypermethrin. In our trials, we did not observe a consistent effect of SPLAT Cida Neo: the formulation applied only during the cycle reduced all the evaluated pest population parameters; however, this reduction was not observed when SPLAT Cida Neo was applied twice during the tomato production cycle. The failure of the double SPLAT Cida Neo application treatment may be explained by the chance positioning, due to randomization of all the treated plots at the edges of the treated fields. These double SPLAT Cida Neo plots probably suffered higher pressure from outside-mated female migration than any other plots, therefore causing this treatment to receive a higher load of viable eggs over time than the other treatments with at least some of the plots protected from strong edge effects.

It is clear that the edge effect is higher when neighbor pest populations are high, and that mating disruption performs better at low pest densities (e.g., see Cardé and Minks 1995). Teixeira et al. (2010) observed that the larval infestation of grape bunches by Paralobesia viteana Clemens was larger at the edges than inside the vineyards, in crops treated with different densities of SPLAT-GBM applied mechanically.

But despite these unfavorable settings, the results of this study indicate that both SPLAT Neo and SPLAT Cida Neo treatments effectively disrupt mating of *N. elegantalis* in the field. This is the first record of the successful use of a commercial sex pheromone mating disruption formulation for the management and control of small tomato borer in open tomato fields. Moreover, the use of these two formulations, namely, SPLAT Neo and SPLAT Cida Neo, have several advantages over the exclusive use of conventional pesticides for pest control, including low cost, biodegradability, water and sunlight resistance, lack of drift, field longevity, and the possibility of mechanical application (Stelinski et al., 2007, 2010). We conclude, therefore, that the application of SPLAT Neo or SPLAT Cida Neo had positive effects in reducing tomato fruit injury in open commercial tomato fields, and that the mating disruption technique using these products will prove to be a promising tool for the management of the small tomato borer in Brazil, more specifically, in the Agreste region of Pernambuco.

**ACKNOWLEDGEMENTS**

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**REFERENCES**


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مدیریت آفت بال پولک دار Neoleucinodes elegantalis
اختلال در جفت‌بایی وروش جلب و نابودی

س. م. فرانکا، ج. و. الیویرا، س. ا. تادجی، س. ا. گودس، ب. ل. دوارت، س. م. الیویرا، و م. ا. بردا

چکیده
برای مبارزه با چندین آفت بال پولک دار، روش اختلال در جفت‌بایی با استفاده از گذشته‌هایی گونه‌ای از SPLAT Neo (یک امولسیون مومی حاوی -E-11-hexadecenol cypermethrin (که از طرفیشان){) از ایجاد اختلال در جفت‌بایی حشره Neoleucinodes elegantalis (Guenée) رشد گیاه برای مصرف گذشته‌های از SPLAT Neo (پریماتونه) نشان داد. همچنین، نیش از دارویی‌هایی از Neoleucinodes elegantalis مشخص شد. در این منطقه، دو آزومن سحرایی اجرای اولیه آزه گربه آزه‌ای (1) یک نوبت تیمار کردن سطح مورد نظر 30 روز بعد از نشان‌گاه گاهچه‌ها با ایجاد اختلال در جفت‌بایی با استفاده از گذشته‌هایی از SPLAT Neo (2) یک نوبت تیمار کردن با cypermethrin (به‌خصوص این‌ها) و (3) یک نوبت تیمار کردن با SPLAT Neo (به‌خصوص این‌ها) با هشته‌ی حشره که در آن یک نوبت مبارزه با آفت به روش خود کشزاران بر منابع برنامه ریزی تقویمی SPLAT Neo مصرف حشره کش‌های سنتی انجام شد. نتایج نشان داد که در مقایسه با تیمار شاهد کار بر نهای حشره کش‌های سنتی انجام شد. نتایج نشان داد که در مقایسه با تیمار شاهد کار بر

برای نهای حشره کش‌های سنتی انجام شد. نتایج نشان داد که در مقایسه با تیمار شاهد کار بر

برای N. elegantalis بوده و بدون SPLAT Neo در طول

در طول N. elegantalis تخم cypermethrin منجر به کاهش معنا‌دار تعداد میانگین تخم cypermethrin بوده و بدون SPLAT Neo در طول

قبل رشد گذشته‌هایی از SPLAT Neo در کنار عبوری که در دو نوبت مصرف شده‌بود تعداد حشره نیز محسوس در تعداد میانگین تخم حشره در مزرعه کمر بود. و صدمات به میوه N. elegantalis این هم‌جهانی که یک دریافت داشته فقط در برداشت کمری در میوه N. elegantalis نتایج حاکی از آن است که مصرف SPLAT Neo در دو نوبت باعث افزایش کمکی میوه N. elegantalis و کاهش معناراد صدمات به میوه N. elegantalis می‌شود.