EFFECT OF WHITEGRUBS (PHYLLOPHAGA SPP.) AND WIREWORMS (DIPROPUS SPP.) ON SUGARCANE YIELD IN GUATEMALA

By

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KEYWORDS: Sugarcane, Whitegrubs, Wireworms, Scarabaeidae, Elateridae, Phyllophaga Dasypoda, Yield Reductions.

Abstract

The study was carried out to determine the effects on potential cane yield of natural infestations of whitegrubs and wireworms in a second ratoon of a commercial sugarcane field planted with cultivar CP72-2086. Twenty-six paired plots (insecticide-treated and untreated) were sampled to measure plant development, density of both root pests from April to December, and cane yield at harvest. The differences in cane yield between treated and untreated plots were calculated and associated with the mean population of whitegrubs and wireworms using a multiple linear regression model. In untreated plots, mean densities of whitegrubs were 16.67 larvae/m² and of wireworms were 10.48 larvae/m², and these plots had reduced plant height and cane yield compared to treated plots. Plant height and cane yields were lower by 4.8% and 11.98 t/ha (16%), respectively, while plant diameter was not affected. The reduction in cane yield was significantly correlated with whitegrub density in untreated plots, but not with wireworm density. The coefficient of cane yield loss was estimated at 0.62 t/ha per whitegrub larva/m² and can be used to estimate the economic injury level for whitegrubs in the sugarcane crop in the low zone of Guatemala, where the whitegrub Phyllophaga dasypoda dominates.

Introduction

Sugar production in Guatemala is affected by a root-pest complex that has adapted to sugarcane plantations in the low zone, living, feeding and reproducing on the introduced crop. Over the past few years, populations have increased, especially of whitegrub and wireworm species. The damage they do is an important factor limiting sugar production. To support technical decisions and economic benefits derived from control strategies, it is necessary to quantify the damage that they do.

Phyllophaga dasypoda, P. latipes and P. parvisetis are the most important species of whitegrub in Guatemalan sugarcane (Ramirez, 2001; Márquez et al., 2002). Other economically important species in the root-pest complex are the wireworms Dipropus spp., Ampedus spp. and Agriotes spp., the cydnid burrowing bug Scaptocoris talpa, the weevil borers Sphenophorus spp. and the termites Heterotermes spp. All of these species can exist together and cause damage to sugarcane roots, depriving plants of moisture and nutrients and, hence, reducing yield. They can also damage underground portions of plants, reducing ratooning capability, making plants susceptible to lodging and leading to loss of stools at harvest. Damage severity is related to pest species, infestation level and critical period of occurrence.

Studies on larvae of endemic melolonthine beetles that affect the sugar industry in Australia report losses of US$8.8 million a year in damage and control cost (Robertson et al., 1995). Losses determined by Wilson (1956) in Queensland in fields with a heavy infestation of white grubs (10–20 larvae/stool) were 13.2 t/ha on average, with the highest average in a single year of 21.13 t/ha. Allsopp et al. (1991) showed

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that each additional larva of *Anthisgus consanguineus* per m² reduced sugar yield by 0.61–0.63 t/ha. Recent studies performed at the Guatemalan Sugar Cane Research and Training Center (CENGICANÁ) indicate that a mean population of 12.5–16.20 whitegrub larvae/m² can reduce cane weight by 5.95–9.62% of potential yield, with losses of 0.88 t/ha for each additional larva/m² present in the field (Márquez and Sandoval, 2003).

Our study aimed to generate information on the composition of the root-pest complex, as well as to quantify the effect of larval density of whitegrubs and wireworms on cane yield at the Limones farm in the Pantaleón/Concepción sugar mill area.

**Materials and methods**

**Location**

The study was performed in collaboration with the Research Department of Pantaleón/Concepción sugar mill. The trial was established on lot No. 0090401 at Limones farm at 46 m above sea level in La Gomera, Escuintla, Guatemala.

**Background**

The 17.84 ha field was considered as one working unit. It was planted with cultivar CP72-2086, and the second-ratoon crop was harvested on 30 January 2003. Preliminary sampling of root-pest populations in May 2003 showed evidence of whitegrub and wireworm infestations with means of 11.37 and 14.96 larvae/m², respectively, with a wide variation across the field, as indicated by standard deviations of 13.48 and 10.26. This variation provided ideal conditions to establish relationships between infestation density and reductions in cane growth and yield. The evaluation period was from April to December 2003.

**Sampling**

We established 26 paired plots across the field to sample different infestation levels and cane growth. Each plot consisted of three contiguous furrows, each 10 m long. One of each paired plot was treated with insecticide to eliminate pest species ('treated') and the other was left untreated. Granular terbufos (CR 3.72 kg/ha) was applied to 10 cm depth adjacent to the furrow in June, granular imidacloprid (16 kg/ha) was applied to the surface of the furrow in August, and chlorpyrifos (1 L/ha) was applied to the surface of the furrow in 500 L of water/ha in October.

We determined the densities of root pests in both treated and untreated plots by sampling in June, August and October. Each time, we excavated a 90 by 50 cm block of soil to 40 cm depth and counted the wireworm larvae and third-instar whitegrubs.

At each sampling, we measured the plant height from the base of five randomly selected stalks from each subplot to the ligule of the first leaf and measured the diameter at the central internode of each of these stalks. Just before harvest in December 2003, we measured the same variables, as well as the number of stalks ready for milling in 5 m of row and the weight of 20 stalks from the central row of each plot. Cane yields were calculated from these stalk measurements.

**Analysis**

Differences in cane yield, plant height and plant diameter between treated and untreated plots were compared with a Student’s paired t-test. The root-pest density in each plot was taken as the mean of the populations in the June, August and October samplings. No insects were found in the treated plots, so the yields of these plots were taken as the potential yields in the absence of root pests. Reductions in cane yield due to root pests were estimated using the difference in cane yield between pairs of treated and untreated plots.

We examined the relationships between pest density and yield loss in each pair of plots with Pearson’s correlation coefficient and quantified significant relationships with multiple linear regression—cane yield (Y) was expressed as a function of mean populations of whitegrubs (X₁) and wireworms (X₂) using the model $Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2$.  

**Results and discussion**

**Pest populations**

Populations of whitegrubs (mean 16.67/m²) were significantly greater than those of wireworms (mean 10.48/m²) in untreated plots (Table 1). However, the numbers of whitegrubs were more variable than those of wireworms; confidence interval (95%) for whitegrubs of 9.17–24.17 larvae/m² compared to 7.67–13.29 wireworms/m². The wide range in pest numbers among untreated plots (whitegrubs 3.70–50.37/m²; wireworms 5.19–22.96/m²) gave good variation for quantifying the effects on crop growth and yield. The cydipid burrowing bug was rare and its presence not significant – numbers are included in the group of ‘other root pests’ found in the sampling.
Crop yield

Cane yield was significantly lower in untreated plots than in treated plots (Table 2), with pest activity causing a reduction of 11.98 t cane/ha or 16% of the potential yield.

After 270 days of growth, stalks were significantly taller (272.02 cm) in treated plots than in the untreated plots (258.95 cm)—a mean reduction of 4.8% in stalk height and, therefore, on stalk weights from pest infestation. However, there was no significant difference in stalk diameter (Table 2).

Table 1—Descriptive statistics of infestation levels in untreated plots.

<table>
<thead>
<tr>
<th>Statistic</th>
<th>Whitegrub larvae/m²</th>
<th>Wireworm larvae/m²</th>
<th>Total root pests Larvae/m²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>16.67</td>
<td>10.48</td>
<td>27.14</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>13.00</td>
<td>4.86</td>
<td>11.79</td>
</tr>
<tr>
<td>Standard error</td>
<td>3.47</td>
<td>1.30</td>
<td>3.15</td>
</tr>
<tr>
<td>Confidence interval (95%)</td>
<td>9.17–24.17</td>
<td>7.67–13.29</td>
<td>20.33–33.95</td>
</tr>
<tr>
<td>Minimum</td>
<td>3.70</td>
<td>5.19</td>
<td>16.30</td>
</tr>
<tr>
<td>Maximum</td>
<td>50.37</td>
<td>22.96</td>
<td>58.52</td>
</tr>
</tbody>
</table>

Table 2—Mean cane yield, height and plant diameter estimated from 26 paired plots (Student’s paired t-test).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Treated</th>
<th>Untreated</th>
<th>Difference</th>
<th>t-test</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cane yield (t/ha)</td>
<td>74.88</td>
<td>62.90</td>
<td>11.98</td>
<td>5.88</td>
<td>0.0001</td>
</tr>
<tr>
<td>Stalk height (cm)</td>
<td>272.02</td>
<td>258.95</td>
<td>13.07</td>
<td>2.39</td>
<td>0.0231</td>
</tr>
<tr>
<td>Stalk diameter (cm)</td>
<td>2.49</td>
<td>2.43</td>
<td>0.06</td>
<td>1.54</td>
<td>0.1354</td>
</tr>
</tbody>
</table>

Correlation analysis

Yield losses were most highly correlated with numbers of whitegrubs and the total number of pest insects (Table 3). The total number of pest insects depended greatly on the number of whitegrubs, while numbers of wireworms were not important determinants of the total number of pest insects.

Table 3—Correlations between loss in cane yield and populations of the root-pest complex.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Correlation coefficient and probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loss in cane yield (t/ha)</td>
<td>Loss in cane yield (t/ha)</td>
</tr>
<tr>
<td>Whitegrubs/m²</td>
<td>0.711</td>
</tr>
<tr>
<td>Wireworms/m²</td>
<td>0.041</td>
</tr>
<tr>
<td>Total number of pest insects/m²</td>
<td>0.715</td>
</tr>
</tbody>
</table>

Regression analysis

Neither the intercept nor the number of wireworms contributed significantly to the multiple regression model (Table 4). Hence, we changed the model to a simple linear regression: \( Y = \beta_1 X_1 \), where \( X_1 \) represents the density of whitegrubs (larvae/m²). The new equation \( Y = 0.62x \) (Figure 1) indicates that, for each additional whitegrub larva per m², a loss of 0.62 t/ha can be expected at harvest.

Table 4. Parameters from multiple linear regression for losses in cane yield and populations of whitegrubs and wireworms.

| Parameter     | Estimate | t for Ho:parameter = 0 | Pr>|t| |
|---------------|----------|------------------------|--------|
| Intercept \((\beta_0)\) | -0.60 | -0.15 | 0.881 |
| White grub \((\beta_1)\) | 0.64 | 5.11 | <0.0001 |
| Wireworm\((\beta_2)\) | 0.34 | 1.14 | 0.265 |
Identification of the whitegrubs from this study using the genitalia of adult males (Márquez et al., 2002) shows that the population at Limones was dominated by *Phyllophaga dasypoda*, with a small proportion of *P. parvisetis* (2%).

The loss at Limones of 0.62 t/ha was lower than the 0.88 t/ha in a similar study at in the Tululá sugar-mill area, where the whitegrub population was 48% *P. dasypoda*, 22% *P. latipes* (22%) and 1% *P. anolaminata*. This difference indicates that environment, pest density, crop variety and pest species can all affect the yield loss.

Of the wireworms at Limones, 88% were *Dipropus* spp. Wireworms did not cause significant losses to cane yield, but may be more important at planting and in ratooning where they damage the buds and new shoots. This requires further study.

Damage by whitegrubs may also affect the yield of the following ratoon crop through a reduction in the number of new shoots produced following harvest (Sosa, 1984; Allsopp et al., 1991, 1995). We need to establish if this occurs in Guatemalan sugarcane.

![Fig. 1—Relationship between cane yield losses (t/ha) and populations of whitegrubs.](image)

Conclusions

Analysis of growth in a second-ratoon crop infested with both whitegrubs and wireworms showed that only whitegrub density showed a significant negative relationship with cane yield. Potential cane yield was reduced by 16% through a reduction in stalk height (4.8%) but not stalk diameter.

Cane yield was reduced by 0.62 t cane/ha for each whitegrub per m². This value can be used in determination of an economic injury level for whitegrub in the low zone of Guatemala when the root-pest complex is dominated by *Phyllophaga dasypoda*.

REFERENCES


EFFETS DES VERS BLANCS (PHYLOPHAGA spp.) ET DES TAUPINS (DIPROPUS spp.) SUR LES RENDEMENTS DE LA CANNE À SUCRE AU GUATEMALA

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MOTS CLÉS: Canne a Sucre, Vers Blancs, Taupins, Scarabaeidae, Elateridae, Phylophaga Dasypoda, Baisses De Rendements.

Résumé

CETTE ÉTUDE a été entreprise dans le but de déterminer les effets des infestations naturelles des vers blancs et des taupins sur le rendement potentiel de la canne à sucre dans des champs commerciaux de la variété CP72-2086 en deuxième repousse. Vingt-six parcelles paires (traitées et non traitées à l’insecticide) ont été échantillonnées d’avril à décembre afin de mesurer le développement de la plante, la densité des deux ravageurs de racines, et les rendements à la récolte. Les différences de rendements entre les parcelles traitées et celles non traitées ont été calculées et associées aux populations moyennes de vers blancs et de taupins suivant un modèle de régression linéaire multiple. Dans les parcelles non traitées, la densité moyenne de vers blancs était de 16.67 larves/m² et celle des taupins de 10.48 larves/m², de plus, la taille de la canne et les rendements étaient plus faibles que dans parcelles traitées. La taille de la canne était inférieure de 4.8% et les rendements étaient plus faibles par 11.98 t/ha, toutefois le diamètre des tiges n’était pas affecté. Il y avait une corrélation significative entre la baisse de rendement et la densité de vers blancs dans les parcelles non traitées, mais il n’y avait pas de corrélation avec la densité des taupins. Le coefficient de baisse de rendement était estimé à 0.62/t/ha/ver blanc /m² et peut être utilisé pour estimer le seuil de nuisibilité économique pour les vers blancs de la canne à sucre dans la partie basse du Guatemala, où le ver blanc Phylophaga dasypoda est prédominant.
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Resumen

EL ESTUDIO se llevó a cabo para determinar los efectos en el rendimiento potencial de la caña de azúcar producidos por la infestación natural de gallina ciega y gusano alambre en un campo comercial del cultivo de segundo corte y cultivado con la variedad CP72-2086. Un total de 26 parcelas pareadas (parcela tratada con insecticida y parcela no tratada) fueron muestreadas para medir el efecto sobre el desarrollo de la planta, la densidad de infestación de ambas plagas de la raíz desde abril a diciembre, así como el rendimiento de caña a la cosecha. La diferencia en el rendimiento de caña entre las parcela ‘tratada’ y ‘no tratada’ fue considerada como la reducción o pérdida que luego fue asociado con la densidad poblacional de larvas de gallina ciega y gusano alambre de la parcela ‘no tratada’ utilizando un modelo de regresión lineal múltiple. En las parcelas no tratadas el promedio de infestación de gallina ciega fue de 16.67 larvas/m² y 10.48 larvas/m² de gusano alambre, lo cual produjo un efecto negativo sobre la altura y rendimiento de caña, comparado con lo observado en las parcelas tratadas. La reducción en altura de planta y rendimiento en peso de caña fue de 4.8 % y 16.82 t/ha (16 %), respectivamente, mientras que el diámetro de planta no fue afectado. La reducción en el rendimiento de caña fue altamente correlacionado con la densidad de gallina ciega, pero no con la densidad de gusano alambre. El coeficiente de pérdida fue estimado en 0.62 t/ha por cada larva/m². Este coeficiente puede utilizarse para estimar el nivel de daño económico de gallina ciega en el cultivo de caña de azúcar en esta región cuya composición del complejo de plagas de la raíz está caracterizada por la predominancia de Phyllophaga dosypoda.