Incidence of *Diatraea saccharalis* attack on irrigated and nitrogen-fertilized sugarcane in Tucumán, Argentina

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**Abstract** Sugarcane production has expanded in non-traditional growing areas in the province of Tucumán that require fertilization and especially irrigation for cultivation. Although *D. saccharalis* has been well studied, it is important to prevent damage to sugarcane under these new conditions. This study aimed to establish the effect of nitrogen fertilization combined with irrigation and vinasse irrigation on *Diatraea* infestation. Four trials were established: 1) a test of four rates (2, 3, 4 and 5 kg/row) of urea (48%N), with and without drip irrigation (eight applications from October to January); 2) one rate (3 kg) of urea with and without surface irrigation (3 applications at 20-day intervals from mid-October to the end of November); 3) two treatments of vinasse (70 m³ containing 1 kg of N/row, 100 m³ containing 1.5 kg of N/row) with irrigation; and 4) three fertilizers, 3.5 kg/row of urea (46%N), 5.5 kg/row of UAN (30%N), and 3.5 kg/row of Nitrodoble (CAN) (27%N). In all cases the infestation intensity was determined from three samples of 10 stalks per replicate. In trial 1, the four urea treatments showed the highest infestation levels. There were no differences in infestation levels between non-irrigated and drip-irrigated plots and the control and the two lower fertilization treatments, but infestations were higher with the two higher fertilizer treatments. In trial 2, there were differences in infestation between the fertilized and unfertilized plots, but not between non-irrigated and surface-irrigated plots. In trial 3, the two vinasses treatments had higher infestation levels than the control, but without a difference between them. In trial 4, infestation levels were higher with urea than with CAN. Overall, nitrogen-fertilized sugarcane increased infestation levels; irrigation did not have a direct influence on borer infestation; and CAN would be useful in that it allows fertilization without increasing *D. saccharalis* incidence.

**Key words** Fertilization, damage, infestation level, borers

**INTRODUCTION** Sugarcane production has expanded in non-traditional growing areas in the province of Tucumán that require fertilization and especially irrigation for cultivation.

Many authors have studied the relationship between nitrogen inputs and pest abundance (particularly aphids and mites) in a wide range of crops (apple, beans, tomato, sorghum, etc.) including sugarcane (Atkinson and Nuss 1989). In South Africa, Goebel et al. (2005) found a positive correlation between nitrogen input and pest infestation levels for the African stalk borer *Eldana saccharina*. Atkinson and Nuss (1989) also observed that increases of *E. saccharina* infestation levels were associated with increased stalk total nitrogen. The insect appears to have invaded sugarcane when stalk nitrogen reached sufficiently high levels for its survival, as a result of intensive cultivation. In Brazil, Bortoli et al. (2005) found that fertilization of *Sorghum bicolor*, in particular nitrogen application, increases *Diatraea saccharalis* levels reducing yield. This response was irrespective of the variety. Bond (1979) suggested that proper management of nitrogen fertilization would become an important means for *Eldana* control in sugarcane. In Cuba, López et al. (1983) studied the effect of 100 kg/ha N nitrogenous fertilization on the incidence of *D. saccharalis* in sugarcane. The application of nitrogen increased the infestation of *Diatraea*, and in split applications, the effect was even greater.

Pannuti et al. (2013) investigated the influence of nitrogen fertilization through drip irrigation on the incidence of *D. saccharalis* in sugarcane and reported a positive correlation between the rate of nitrogen and the number of holes caused by the sugarcane borer. However, despite a reduction in cane quality, nitrogen fertilization enhanced biomass yield and sugar yield. Pannuti et al. (2014) found that increased biomass and sugar yields due to N fertilization compensated for the effects of combined borer and stalk rot. They also showed that stalks produced with increased N fertilization were consumed more by *D. saccharalis*.
However, little is known about fertilization effect on borer incidence under the conditions in Tucumán, Argentina. The objective of our study was to establish the incidence of nitrogen fertilization combined with irrigation and vinasse/irrigation on *D. saccharalis* infestation.

**MATERIALS AND METHODS**

To assess the attack of *D. saccharalis* in sugarcane when fertilized with nitrogen we established four trials. The variety LCP 85-384 was used in all trials.

Trial 1 was carried at La Cruz (Burruyacú Department). We used a randomized complete-block design with four different doses to test four rates (2, 3, 4 and 5 kg/row) of urea (48%N), with and without drip irrigation in eight applications from October to January. Plots were of six rows 20 m long with three replicates. Foliar samples were taken to determine N levels in leaves in all N rates in the drip-irrigation treatment and in non-irrigation only for the conventional N rate (3 kg N). In all cases Leaf+1 (first leaf with ligule) was sampled from 08:00 to 11:00. Each sample comprised 25-30 leaves in optimal conditions according to McCray et al. (2011). The samples were put in paper bags, cooled and taken to the laboratory to be processed within the following 24 hours.

Trial 2 evaluated the effects of surface irrigation and nitrogen fertilization on *Diatraea* incidence at Fronterita (Famaillá Department). We combined 3 kg of urea (48%N) with and without surface irrigation in applications moments each 20 days from mid-October to the end of November in 2012. Each plot was 10 rows of 30 m and there were three replicates of each treatment.

Trial 3 determined *D. saccharalis* incidence when vinasse, as the source of nitrogen, was applied. There were two treatments of vinasse, 70 m³ containing 1 kg of N/100 m row and 100 m³ containing 1.5 kg of N/100 m row. Each plot had 6 rows of 30 m and there were three replicates of each treatment. We evaluated four rows of 20 m for each treatment. The trial was in Arcadia (Chicligasta department), in 2010.

Trial 4 evaluated *D. saccharalis* incidence after application of UAN (urea and ammonium nitrate) and CAN (calcium ammonium nitrate), alternative synthetic nitrogen sources (commercial rates). We applied urea (46%N) at 3.5 kg/row, UAN (30%N) at 5.5 kg/row and CAN (27%N) at 3.5 kg/row, in 10 rows of 300 m plots with three replicates at La Cruz (Cruz Alta Department) in 2014.

From each plot in each trial we took three samples of 10 stalks to the laboratory for quality analysis. Each sample was weighed, juice was extracted and analyzed, and sugarcane pol %, Brix and fiber were determined. All sucrose parameters were determined at the chemistry laboratories of Estación Experimental Agroindustrial Obispo Colombres (EEAOC). Differences among treatments were evaluated by means of ANOVA followed with Duncan’s multiple range test.

**RESULTS AND DISCUSSION**

In trial 1, we found significant differences in the infestation intensity between the unfertilized control and all four doses of nitrogen in the drip-irrigated plots. In the non-irrigated plots there were no differences between the control and the two lower N rates, but there were significant differences with the two higher nitrogen rates (Table 1). Regardless of the type of irrigation, the infestation intensity increased when doses of nitrogen were higher. No difference was found between the two highest doses (4 and 5 kg N) (Table 1).

To determine any relationship between effects of *D. saccharalis* incidence with increasing nitrogen on sugar yield, we carried out two harvests during June and August (Table 1). There were no differences with higher nitrogen fertilization in the June yield for both irrigated and non-irrigated treatments. In the August harvest sugar yields were higher with the two highest nitrogen rates (4 and 5 kg N) in both the irrigated and non-irrigated plots.

In the drip-irrigated plots, foliar N concentration (% N leaf+1) in fertilized treatments increased as the N rate increased (Table 1). In all cases, the concentration of N in leaf was above the 1.8% level considered as critical for proper N nutrition (Pérez Zamora 2005; McCray et al. 2011). At the rate of 3 kg N (48%), the drip-irrigation treatment had a significantly higher N level than the non-irrigated treatment. This indicated that when the concentration of nitrogen in leaves was higher, *D. saccharalis* incidence increased.
Table 1. Average infestation intensities of *Diatrea saccharalis*, sugar yield and leaf-nitrogen levels under different irrigation and fertilizer treatments.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Infestation intensity (%)</th>
<th>Sugar yield (t/ha) June</th>
<th>Sugar yield (t/ha) August</th>
<th>% N leaf+1</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-N (48%)</td>
<td>3.82 a</td>
<td>11.98 a</td>
<td>12.08 a</td>
<td>1.95 ab</td>
</tr>
<tr>
<td>2-N (48%)</td>
<td>9.97 b</td>
<td>11.70 a</td>
<td>11.62 a</td>
<td>2.01 bc</td>
</tr>
<tr>
<td>3-N (48%)</td>
<td>12.07 b</td>
<td>11.44 a</td>
<td>10.98 a</td>
<td>2.09 cd</td>
</tr>
<tr>
<td>4-N (48%)</td>
<td>16.58 c</td>
<td>11.10 a</td>
<td>9.95 b</td>
<td>2.12 cd</td>
</tr>
<tr>
<td>5-N (48%)</td>
<td>17.77 c</td>
<td>10.97 a</td>
<td>9.15 b</td>
<td>2.20 d</td>
</tr>
</tbody>
</table>

Values within a trait followed by different letters are significantly different (Tuckey-test, P < 0.05).

Trial 2 compared surface irrigation and non-irrigation, with and without nitrogen fertilization. There was no significant effect of irrigation on *D. saccharalis* incidence, but nitrogen fertilization increased the intensity of infestation (Table 2). However, this difference did not translate to a significant difference in sugar yield.

Table 2. Average infestation intensities of *Diatraea saccharalis* and sugar yield under different irrigation and fertilizer treatments.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Infestation intensity (%)</th>
<th>Sugar yield (t/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface irrigation</td>
<td>4.48 a</td>
<td>12.16 a</td>
</tr>
<tr>
<td>Surface irrigation + N</td>
<td>8.39 b</td>
<td>12.68 a</td>
</tr>
<tr>
<td>No irrigation</td>
<td>2.26 a</td>
<td>11.95 a</td>
</tr>
<tr>
<td>No irrigation + N</td>
<td>6.58 b</td>
<td>12.06 a</td>
</tr>
</tbody>
</table>

Values within a trait followed by different letters are significantly different (Tuckey-test, P < 0.05).

Trial 3 shows the relationship between two concentrations of vinasse applied and *D. saccharalis* attack at two different harvests dates, in June and August. Both vinasse treatments significantly increased borer incidence at both harvests. There was a trend to higher infestation in the 100 m$^3$ rate than in the 70 m$^3$ rate, but the differences were not statistically significant. Sugar yield showed no differences among treatments at both harvest dates (Table 3).

Table 3. Average infestation intensities of *Diatraea saccharalis* and sugar yield in June and August for different vinasse doses.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>June</th>
<th>August</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infestation intensity (%)</td>
<td>Sugar yield (t/ha)</td>
<td>Infestation intensity (%)</td>
</tr>
<tr>
<td>Control</td>
<td>0.98 a</td>
<td>12.04 a</td>
</tr>
<tr>
<td>Vinasse 70 m$^3$</td>
<td>5.17 b</td>
<td>12.49 a</td>
</tr>
<tr>
<td>Vinasse 100 m$^3$</td>
<td>8.16 b</td>
<td>12.65 a</td>
</tr>
</tbody>
</table>

Values within a trait followed by different letters are significantly different (Tuckey-test, P < 0.05).

Trial 4 tested the effect of alternative nitrogen sources on *D. saccharalis* incidence compared with urea fertilization. There were lower incidences of *D. saccharalis* where CAN was used, followed by where UAN was used (Table 4). Highest incidence was where urea was applied. No significant differences were observed between UAN and the control (Table 4).

Although CAN had only 60% of N than urea, it gave significant higher sugar yields than urea (Table 4). This may be explained by the different assimilation and volatilization characteristics of the two forms of N fertilizer.
CONCLUSIONS

- Nitrogen fertilization increased borer infestation in sugarcane.
- Sugar yield was affected by *D. saccharalis* only after high rates of N fertilization.
- Irrigation did not have a direct influence on borer infestation.
- CAN allows fertilization without an increase in *D. saccharalis* attack, and so might be a useful management tool.

REFERENCES


Incidence des *Diatraea saccharalis* de l’attaque sur la canne à sucre irriguée et l’azote fécondé dans Tucumán, Argentine

Résumé. La production de canne à sucre s’est étendue aux zones de culture non traditionnelles dans la province de Tucumán, ce qui demande une fertilisation et particulièrement de l’irrigation pour conduire la culture. Bien que *D. saccharalis* ait été bien étudié, il est important de prévenir les dégâts à la canne à sucre sous ces nouvelles conditions. Cette étude a pour objectif d’établir l’effet de la fertilisation azotée combiné avec l’irrigation et l’irrigation avec la vinasse sur les infections de ce ravageur. 4 expérimentations ont été établis pour : 1) un test de 4 doses d’urée à 48% d’azote (2, 3, 4 et 5 kg/rag), avec ou sans irrigation en goutte à goutte (8 applications d’octobre à janvier), 2) une seule dose d’urée (3 kg) avec ou sans irrigation de surface (3 applications à 20 jours d’intervalle de mi-octobre à la fin du mois de novembre) ; 3) deux traitements de vinasse (70 m² contenant 1 kg de N/rang, 100 m² contenant 1.5 kg de N/rang avec irrigation et 4) trois types engrais, 3.5 kg/rag d’urée (46% N), 5.5 kg/rag de UAN (30%N), and 3.5 kg/rag de Nitrodoble (CAN) (27% N). Dans tous les cas, l’intensité d’infestation a été déterminée à partir de 3 échantillons de 10 tiges par répétition. Dans le test 1, les 4 doses d’application d’urée ont montré les plus forts niveaux d’infestation. Il n’y avait pas de différence de niveaux d’infestation entre les parcelles non irriguées et irriguées en goutte à goutte et le témoin, et les 2 plus faibles doses de fertilisants, mais les infestations étaient plus élevées avec les 2 plus fortes doses de fertilisants. Dans le test 2, des différences d’infestation ont été constatées entre les parcelles fertilisées et non fertilisées, mais pas entre les parcelles irriguées (surface) et non irriguées. Dans le 3ème test les 2 traitements en vinasse ont engendré plus d’infestation que dans le témoin, mais sans différence entre eux. Dans le test 4, les niveaux d’infestations étaient supérieurs avec l’urée qu’avec le CAN. Globalement, la fertilisation azotée sur canne augmente les niveaux d’infestation des borers.
Incidencia del ataque de Diatraea saccharalis en caña de azúcar con riego y fertilización nitrogenada en Tucumán, Argentina

Resumen. La producción de caña se extendió hacia las áreas de cultivo no tradicionales en la provincia de Tucumán que necesitaron fertilización y en particular riego para el cultivo. Aunque D. saccharalis fue bien estudiada, es importante su evaluación para evitar daños a la caña de azúcar en estas nuevas condiciones. Este estudio tuvo como objetivo determinar el efecto de la fertilización nitrogenada combinada con el riego y riego con vinaza en infestaciones de Diatraea. Se establecieron cuatro ensayos: 1) El primer ensayo fue de cuatro dosis (2, 3, 4 y 5 kg / surco) de urea (48% N), con y sin riego por goteo (ocho aplicaciones de octubre a enero); 2) una dosis (3 kg de urea) con y sin riego superficial (3 aplicaciones a intervalos de 20 días desde mediados de octubre hasta finales de noviembre); 3) dos tratamientos de riego con el agregado de vinaza (70 m³ que contienen 1 kg de N / surco, 100 m³ que contiene 1,5 kg de N / surco); y 4) se probaron tres fertilizantes, urea (46% N) 3,5 kg / surco, UAN (30% N) 5,5 kg / surco y Nitrodoble (CAN) (27% N) 3,5 kg / surco. En todos los casos se determinó la intensidad de la infestación en tres muestras de 10 tallos por repetición. En el primer ensayo, las cuatro dosis de urea mostraron niveles altos de infestación. En las dosis más bajas no hubo diferencias en los niveles de infestación entre las parcelas irrigadas y no irrigadas y el control, pero las infestaciones fueron mayores en los dos tratamientos con fertilización más altas. En el ensayo 2, hubo diferencias significativas en la infestación entre las parcelas fertilizadas y no fertilizadas, pero no entre las parcelas de secano y riego en superficie. En el ensayo 3, los dos tratamientos con vinaza el nivel de infestación fue más alto que el control, pero sin diferencia entre ellos. En el ensayo 4, los niveles de infestación fueron mayores con la urea que con el CAN. En general, la caña de azúcar fertilizada con nitrógeno presentó niveles de infestación más altos; las parcelas regadas no presentaron una influencia directa sobre la infestación del barrenador; y la fertilización con CAN sería útil, ya que permite la fertilización de la caña de azúcar sin aumentar la incidencia D. saccharalis.

Palabras claves: Fertilización, daño, nivel de infestación, perforadores