1987

Bionomics of the Sugarcane Borer, Diatraea Saccharalis (F.), in Sweet Sorghum, Sorghum Bicolor (L.) Moench.

Billy Wayne Fuller

Louisiana State University and Agricultural & Mechanical College

Follow this and additional works at: https://digitalcommons.lsu.edu/gradschool_disstheses

Recommended Citation

https://digitalcommons.lsu.edu/gradschool_disstheses/4447

This Dissertation is brought to you for free and open access by the Graduate School at LSU Digital Commons. It has been accepted for inclusion in LSU Historical Dissertations and Theses by an authorized administrator of LSU Digital Commons. For more information, please contact gradetd@lsu.edu.
INFORMATION TO USERS

The most advanced technology has been used to photograph and reproduce this manuscript from the microfilm master. UMI films the original text directly from the copy submitted. Thus, some dissertation copies are in typewriter face, while others may be from a computer printer.

In the unlikely event that the author did not send UMI a complete manuscript and there are missing pages, these will be noted. Also, if unauthorized copyrighted material had to be removed, a note will indicate the deletion.

Oversize materials (e.g., maps, drawings, charts) are reproduced by sectioning the original, beginning at the upper left-hand corner and continuing from left to right in equal sections with small overlaps. Each oversize page is available as one exposure on a standard 35 mm slide or as a 17" × 23" black and white photographic print for an additional charge.

Photographs included in the original manuscript have been reproduced xerographically in this copy. 35 mm slides or 6" × 9" black and white photographic prints are available for any photographs or illustrations appearing in this copy for an additional charge. Contact UMI directly to order.
Bionomics of the sugarcane borer, *Diatraea saccharalis* (F.), in sweet sorghum, *Sorghum bicolor* (L.) Moench

Fuller, Billy Wayne, Ph.D.
The Louisiana State University and Agricultural and Mechanical Col., 1987
PLEASE NOTE:

In all cases this material has been filmed in the best possible way from the available copy. Problems encountered with this document have been identified here with a check mark √.

1. Glossy photographs or pages ______
2. Colored illustrations, paper or print ______
3. Photographs with dark background ______
4. Illustrations are poor copy ______
5. Pages with black marks, not original copy ______
6. Print shows through as there is text on both sides of page ______
7. Indistinct, broken or small print on several pages √
8. Print exceeds margin requirements ______
9. Tightly bound copy with print lost in spine ______
10. Computer printout pages with indistinct print ______
11. Page(s) ______ lacking when material received, and not available from school or author.
12. Page(s) ______ seem to be missing in numbering only as text follows.
13. Two pages numbered ______. Text follows.
14. Curling and wrinkled pages ______
15. Dissertation contains pages with print at a slant, filmed as received ______
16. Other _________________________________

________________________________________

________________________________________

_____________________________

UMI
BIONOMICS OF THE SUGARCANE BORER,
Diatraea saccharalis (F.),
IN SWEET SORGHUM, Sorghum bicolor (L.) moench

A Dissertation
Submitted to the Graduate Faculty of the
Louisiana State University and
Agricultural and Mechanical College
in partial fulfillment of the
requirements for the degree of
Doctor of Philosophy
in
The Department of Entomology

by
Billy Wayne Fuller
A.A., Southern Union State Junior College 1974
B.S., Auburn University 1976
M.Ed., Auburn University 1978
M.S. Clemson University 1982
December 1987
ACKNOWLEDGEMENTS

I wish to express my appreciation to Dr. Thomas E. Reagan who has served as my major advisor. My advisory committee consisting of Drs. Sharron S. Quisenberry, Jerry B. Graves, Lynn M. Kitchen, Freddie A. Martin, John B. Baker and Elvis A. Heinrichs deserve special thanks for their assistance in all aspects of my research program. Also, Dr. Arnold M. Saxton's assistance in design and analyses of these studies was invaluable.

Jeff L. Flynn and Ricardo T. Bessin were especially helpful in collection of data. I am unable to list all the people who have assisted me at Louisiana State University, but my sincere appreciation is felt for everyone involved.

Also, I would like to thank Mr. Price Gay and Mr. John Gay of Plaquemine, Louisiana for allowing the use of their farm as a site for the predation study. Sweet sorghum seeds for these experiments were graciously provided by John H. Holcomb of Progreso, Texas.

Family and friends have been the most valuable asset in pursuit of my education goals. Their help has made all the difficult times far less unpleasant.
<table>
<thead>
<tr>
<th>TABLE OF CONTENTS</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACKNOWLEDGEMENTS</td>
<td>ii</td>
</tr>
<tr>
<td>TABLES OF CONTENTS</td>
<td>iii</td>
</tr>
<tr>
<td>LIST OF TABLES</td>
<td>v</td>
</tr>
<tr>
<td>LIST OF FIGURES</td>
<td>vii</td>
</tr>
<tr>
<td>ABSTRACT</td>
<td>viii</td>
</tr>
<tr>
<td>INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>LITERATURE REVIEW</td>
<td>3</td>
</tr>
<tr>
<td>CHAPTER I</td>
<td></td>
</tr>
<tr>
<td>Economic Injury Level of the Sugarcane Borer (Lepidoptera: Pyralidae) on Sweet Sorghum</td>
<td>8</td>
</tr>
<tr>
<td>Introduction</td>
<td>9</td>
</tr>
<tr>
<td>Materials and Methods</td>
<td>10</td>
</tr>
<tr>
<td>Results</td>
<td>12</td>
</tr>
<tr>
<td>Discussion</td>
<td>18</td>
</tr>
<tr>
<td>References Cited</td>
<td>22</td>
</tr>
<tr>
<td>CHAPTER II</td>
<td></td>
</tr>
<tr>
<td>Comparative Predation of the Sugarcane Borer (Lepidoptera: Pyralidae) on Sweet Sorghum and Sugarcane</td>
<td>24</td>
</tr>
<tr>
<td>Introduction</td>
<td>25</td>
</tr>
<tr>
<td>Materials and Methods</td>
<td>25</td>
</tr>
<tr>
<td>Results</td>
<td>28</td>
</tr>
<tr>
<td>Discussion</td>
<td>36</td>
</tr>
<tr>
<td>References Cited</td>
<td>40</td>
</tr>
</tbody>
</table>
TABLE OF CONTENTS (continued)

<table>
<thead>
<tr>
<th>CHAPTER III</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant Stand Density Effects on the Sugarcane Borer</td>
<td></td>
</tr>
<tr>
<td>(Lepidoptera: Pyralidae) in Sweet Sorghum</td>
<td>42</td>
</tr>
<tr>
<td>Introduction</td>
<td>43</td>
</tr>
<tr>
<td>Materials and Methods</td>
<td>44</td>
</tr>
<tr>
<td>Results</td>
<td>46</td>
</tr>
<tr>
<td>Discussion</td>
<td>50</td>
</tr>
<tr>
<td>References Cited</td>
<td>53</td>
</tr>
<tr>
<td>SUMMARY</td>
<td>55</td>
</tr>
<tr>
<td>LIST OF REFERENCES</td>
<td>58</td>
</tr>
<tr>
<td>APPENDICES</td>
<td>63</td>
</tr>
<tr>
<td>A. Soil Surface Associated Spider Fauna of Sweet</td>
<td>64</td>
</tr>
<tr>
<td>Sorghum and Adjacent Sugarcane</td>
<td></td>
</tr>
<tr>
<td>B. Small Plot Insecticidal Screening Study in</td>
<td>66</td>
</tr>
<tr>
<td>Sweet Sorghum</td>
<td></td>
</tr>
<tr>
<td>C. Copyright Permission</td>
<td>69</td>
</tr>
<tr>
<td>VITA</td>
<td>73</td>
</tr>
</tbody>
</table>

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
LIST OF TABLES

Table       Page

CHAPTER I. Economic Injury Level of the Sugarcane Borer (Lepidoptera: Pyralidae) on Sweet Sorghum.

1. Larval survival, adult emergence and yield of total sugars as affected by various early-late infestation levels of D. saccharalis larvae on sweet sorghum at St. Gabriel, La., in 1985 ................................ 13

2. Effects of D. saccharalis on yield and quality of total sugars for sweet sorghum at St. Gabriel, La., in 1984-85 ....................... 16

CHAPTER II Comparative Predation of the Sugarcane Borer (Lepidoptera: Pyralidae) on Sweet Sorghum and Sugarcane.

1. Mean number x 10² per week of canopy associated arthropods per ha in sweet sorghum and adjacent plant cane, collected from weekly destructive samples, Iberville Parish, La., in 1985 ........................................ 29

2. Mean number x 10² per week of canopy associated arthropods per ha in sweet sorghum and adjacent first-ratoon sugarcane, collected from weekly destructive samples, Iberville Parish, La., in 1986 ......................... 30

3. Mean number per pitfall trap of arthropods associated with the soil surface in sweet sorghum and adjacent plant cane, collected every two weeks, Iberville Parish, La., in 1985 ........................................ 31

4. Mean number per pitfall trap of arthropods associated with the soil surface in sweet sorghum and adjacent first-ratoon sugarcane, collected every two weeks, Iberville Parish, La., in 1986 ......................... 34

5. Percent D. saccharalis bored internodes, larval survival and total moth emergence determined from harvest records for sweet sorghum and sugarcane, Iberville Parish, La., in 1985-1986 ...................... 35

v

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
CHAPTER III. Plant Stand Density Effects on the Sugarcane Borer (Lepidoptera: Pyralidae) in Sweet Sorghum.

1. Sweet sorghum planting stand effects on D. saccharalis larval survival, damage indices, and yield of total sugars at St. Gabriel, La., in 1984 and 1986 ............ 48

APPENDIX A. Soil Surface Associated Spider Fauna of Sweet Sorghum and adjacent sugarcane.

1. Mean number of soil surface associated spiders in sweet sorghum and adjacent sugarcane, collected from biweekly pit-fall trap samples, Iberville Parish, La., in 1985 ......................... 65

APPENDIX B. Small Plot Insecticidal Screening Study in Sweet Sorghum.

1. Sugarcane borer control in sweet sorghum using insecticidal treatments compared with check plots at St. Gabriel, La., 1986 ............................................. 68
# LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHAPTER I. Economic Injury Level of the Sugarcane Borer (Lepidoptera: Pyralidae) on Sweet Sorghum.</td>
<td></td>
</tr>
<tr>
<td>1. Sweet sorghum yield loss and Brix reductions attributed to <em>D. saccharalis</em> larval damage at St. Gabriel, La., during 1984-85</td>
<td>15</td>
</tr>
<tr>
<td>2. Sweet sorghum yield of total sugars as affected by <em>D. saccharalis</em> bored internode damage at St. Gabriel, La., during 1984-85</td>
<td>17</td>
</tr>
<tr>
<td>CHAPTER III. Plant Stand Density Effects on the Sugarcane Borer (Lepidoptera: Pyralidae) in Sweet Sorghum.</td>
<td></td>
</tr>
<tr>
<td>1. Mean weekly <em>D. saccharalis</em> larval infestation estimates for differing planting densities of sweet sorghum at St. Gabriel, La., in 1984 and 1986</td>
<td>46</td>
</tr>
<tr>
<td>2. Mean sweet sorghum plant height (cm) in relation to sweet sorghum planting density at St. Gabriel, La., 1984</td>
<td>48</td>
</tr>
</tbody>
</table>
ABSTRACT

Economic impact studies revealed that the sugarcane borer, *Diatraea saccharalis* (F.), reduced sweet sorghum yield of total sugars up to 46% in artificially infested field trials. A significant relationship was found between *D. saccharalis* damage and yield loss that indicated an economic injury level of 10% bored internodes. Stalk weight, percent sucrose, and total sugars were negatively correlated to *D. saccharalis* damage; and increased fiber content was positively correlated to percent bored internodes. Information from damage levels, along with survival records, indicated that the economic threshold was reached when approximately 5% of the sweet sorghum plants contained small *D. saccharalis* larvae in their leafsheaths.

Comparisons of the predator-prey relationship between sweet sorghum and sugarcane plots revealed that the arthropod predator composition was similar for both crops, but predator abundance in sugarcane was 4- and 16-fold greater than that found in sweet sorghum during 1985 and 1986, respectively. Predator habitat disruption associated with cultivation practices in sweet sorghum and sugarcane is important in this relationship. The red imported fire ant, *Solenopsis invicta* Buren, was the dominant arthropod predator found in pitfall traps and canopy samples of each crop. Based upon pitfall trap determinations, carabid larvae, cicindelids, and the Araneae were significantly more
abundant predators in sweet sorghum compared with sugarcane. Also populations of carabid larvae, chrysopids and Orius spp. were significantly greater in sweet sorghum canopy samples. Reduced damage by D. saccharalis in plots without predator suppression resulted in 22.4 and 18.6% greater yield of total sugars in sweet sorghum and sugarcane plots, respectively. Compared with sugarcane 'CP74-383', D. saccharalis larval survival inside stalk tunnels was significantly greater in sweet sorghum 'Wray' during 1985. Predators reduced D. saccharalis moth emergence in both crops by approximately 50% in 1986.

A two year study was conducted to evaluate the effects of sweet sorghum stalk barrel diameter and fiber content on D. saccharalis populations. Larval survival and moth emergence were not significantly effected by resultant increased fiber content that accompanied decreased stalk barrel diameter.
INTRODUCTION

Interest in alternate energy sources has led to the recent increase in sweet sorghum, *Sorghum bicolor* (L.) Moench, acreage for the production of ethanol; thus, reducing United States consumption of gasoline produced from costly and unreliable foreign crude oil. Louisiana acreage records for sweet sorghum are not maintained; however, very little sweet sorghum was grown in the state, prior to the 1980's. Previously, sweet sorghum was grown primarily for making syrup and molasses. Agronomic studies by Ricaud & Arceneaux (1984) indicated the usefulness of sweet sorghum for biomass and alcohol production. Initial planting trials for producing ethanol were successful and since the early 1980's ethanol production facilities have been constructed (Pollack 1984).

Proactive research was required concerning management considerations of sweet sorghum in the sugarcane agroecosystem of south Louisiana. Therefore, a sound understanding of the bionomics of the sugarcane borer reared on sweet sorghum would precede any future increase of acreage of this crop. Thus, research would precede any pest management disruptions caused by the introduction of sweet sorghum into the sugarcane growing region of south Louisiana. Studies were conducted to ascertain the following:

1) to determine the economic injury level based on the percent bored internode damage and associated reductions
in yield attributed to *D. saccharalis*.

2) to determine an economic threshold level from small plot insecticidal screening studies that would prevent the *D. saccharalis* damage from surpassing the economic injury level on sweet sorghum,

3) to investigate the role of changing cultivation practices in the annual (sweet sorghum) and perennial (sugarcane) crops' predator-prey relationships,

4) to ascertain whether increasing plant stand density (which causes decreased stalk barrel diameter and an associated increase in fiber content) could be used as a cultural practice to reduce *D. saccharalis* larval survival, and

5) to determine *D. saccharalis* adult emergence in a susceptible sugarcane variety 'CP74-383' and adjacent sweet sorghum 'Wray' from an area-wide perspective.

Pursuit of these objectives will collectively provide a comprehensive investigation of the bionomics of *D. saccharalis* in sweet sorghum. Thus, implementation of management and production strategies may be adjusted to prevent any major problems that may arise in associated future increases in sweet sorghum acreage in Louisiana.
LITERATURE REVIEW

The Sugarcane Borer

Fabricius first described the sugarcane borer as Phalaena saccharalis in 1794, and Hampton in 1895 placed in the genus Diatraea (Dyar & Heinrich 1927). This key pest of sugarcane is member of the family Pyralidae in the order Lepidoptera. Diatraea saccharalis (F.) attacks several crops in the family Gramineae including sugarcane, Saccharum officinarum L.; corn Zea mays L.; rice Oryza sativa L.; and sweet sorghum, Sorghum bicolor (L.) Moench (Long & Hensley 1972). In southern Louisiana, more than 90% of all insect related damage to sugarcane is attributed to Diatraea saccharalis (Reagan et al. 1972).

The sugarcane borer tunnels through internal stalk tissues which causes severe yield loss in untreated sugarcane fields. It is responsible for an estimated annual economic loss of 13% statewide (Pollet et al. 1978). Impact of D. saccharalis stalk tunnelling damage ranges from direct yield losses due to reduced uptake of water and nutrients to death of the upper portions of stalks in heavily damaged plants. Additional reductions in yield may result from lodging at D. saccharalis weakened internodes or entry of pathogens through larval tunnels (Reagan & Flynn 1986).

Sweet Sorghum

Cultivation records of sweet sorghum can be traced back to ancient Assyria around 700 B. C. where palace wall carv-
ings show the importance of this crop (Walls & Ross 1970). Sweet sorghum has been grown for centuries in China for sugar and alcohol production (Olcott 1857). Louisiana has the distinction of being one of the first areas in the United States to grow sweet sorghum. In the late 1850's sugar was first produced from sweet sorghum in Louisiana (Olcott 1857), and Leonard Wray is credited with introducing several varieties of sweet sorghum into the United States from Africa in 1854 (Walls & Ross 1970).

Sweet sorghum was viewed by early United States researchers in the 1850's as a "wonder crop" (Olcott 1857). Although this crop has desirable traits, it has provided relatively little competition to the world's two major sugar crops (sugarcane, and sugar beets). Though the acreage data for this crop are not collected by the United States Department of Agriculture (Brown 1980), it is being grown on a small scale in 19 states (Freeman et al. 1973). This production has usually been limited to small farms with less than 0.4 ha of land planted in sweet sorghum. Its limited use for sugar production is due to the high starch content and rapid inversion of sucrose (Ricaud & Arceneaux 1984), but other scientists report that "high levels of starch and aconitic acid" problems have been overcome by USDA chemists, and mills runs on sweet sorghum have produced raw sugar of acceptable quality" (Irvine 1980). Regardless of its value for sugar production, possibilities exist for using sweet sorghum as a feeder stock to produce ethanol for use in
gasohol or as an octane enhancer in gasoline.

In recent years, sweet sorghum has been improved to overcome many of its early disease problems. Some experts predict that sweet sorghum will be cultivated on more than 5.7 million ha in the United States by the year 2000 with an annual alcohol production of 31.4 billion liters (Nathan 1979).

Several characteristics of sweet sorghum are expected to lead to increased acreage throughout the United States. Sweet sorghum has a very rapid maturation rate (90-150 days from planting to harvest) as compared to other sugar crops. Potentially, sweet sorghum has a wide United States geographical growing range, since this crop could be grown from Alabama to Minnesota, and anywhere corn, *Zea mays* L., is cultivated (Nathan 1979). This crop has a lower water requirement than other sugar crops. It needs less water than sugarcane and has been found to be more drought tolerant than corn (Nathan 1979). Growing of early crops of sweet sorghum has the potential to complement sugarcane rather than directly compete for existing processing facilities. Sweet sorghum could be harvested prior to sugarcane; thus, extending grinding season and allow for increased working hours for seasonal employees. Ratooning of sweet sorghum plants would provide a second crop within the same growing season that would be especially practical in regard to biomass production of alcohol. These characteristics make sweet sorghum's future appear hopeful for sugar and alcohol production.
production in Louisiana agriculture.

**Insect Pest Management**

A 1.4-fold increase in the number of *D. saccharalis* pupae was found in sweet sorghum 'Wray' when compared with adjacent plots of moderately resistant sugarcane 'CP65-357' (Reagan & Flynn 1986), which prompted their warning that increased acreage of highly susceptible alternate host crops (e.g. corn and sweet sorghum) could have a serious impact on sugarcane insect pest management.

Hensley (1971) initiated a sugarcane insect pest management program which has proven highly successful in Louisiana. This program judiciously utilizes insecticides at economic thresholds and has been strongly supported by a varietal resistance component (Reagan & Martin 1987). Varietal resistance mechanisms to *D. saccharalis* in sugarcane include leafsheath appression, rind hardness, and high fiber content (Coburn & Hensley 1972, Martin et al. 1975, Reagan & Martin 1987). Research involving resistance to *D. saccharalis* in sweet sorghum has been limited to a two-trial study conducted in Sao Paulo, Brazil (Lara & Perussi 1984). In the first trial, a significant (*r = 0.52, P < 0.05*) positive correlation was found between percent *D. saccharalis* larval infestation and increased diameter at the median internode of sweet sorghum stalks. Although, the second trail was inconclusive this study suggests that decreasing sweet sorghum stalk barrel diameter could be used to reduce *D. saccharalis* larval populations.
Composition of the arthropod predator complex and its role in controlling *D. saccharalis* larvae has been investigated intensively (Negm & Hensley 1968, 1972, Reagan et al. 1972, Ali & Reagan 1985). Similar predator assessments for the sweet sorghum agroecosystem has not been previously studied in Louisiana.
CHAPTER I

Economic Injury Level of the Sugarcane Borer (Lepidoptera: Pyralidae) on Sweet Sorghum.

The following chapter is modified from manuscript J87-007, which was accepted by the Journal of Economic Entomology and is currently in press.
Introduction

Sweet sorghum, *Sorghum bicolor* (L.) Moench, is being used on a trial basis as part of a government subsidized program to produce ethanol in Louisiana. The rapid maturation of sweet sorghum (90-150 d), drought tolerance, its wide geographical growing range from Alabama to Minnesota, and technological breakthroughs in sugar extraction may lead to rapid increase in production for this crop (Nathan 1979).

The sugarcane borer, *Diatraea saccharalis* (F.), is a serious pest of several crops in the family Gramineae including sugarcane, *Saccharum officinarum* L.; corn *Zea mays* L.; rice *Oryza sativa* L.; and sweet sorghum (Long & Hensley 1972). The impact of *D. saccharalis* stalk tunnelling damage ranges from direct yield losses due to reduced uptake of water and nutrients to death of the upper portions of stalks in heavily damaged plants. Additional reductions in yield may result in lodging at *D. saccharalis* weakened internodes or entry of pathogens through larval tunnels (Reagan & Flynn 1986).

Introduction of sweet sorghum into Louisiana may create management problems for sugarcane growers due to a potential increase in *D. saccharalis* populations from production of this alternate host crop. The goal of this study was to develop an economic threshold that would be used to assist in pest management decisions for control of *D. saccharalis* on sweet sorghum.
Materials and Methods

Sweet sorghum 'Wray' was planted in single row plots with 0.91 m spacing, (7.62 m long, 0.0006 ha), between two border rows on 28 April 1984 and 19 April 1985 on the St. Gabriel Research Station, Iberville Parish, Louisiana. Commerce silt loam and Sharkey clay soil types characterized field locations for 1984 and 1985 plots, respectively. An average of 41 (57,383 per ha) and 35 (50,210 per ha) plants per plot were artificially infested with first instar *D. saccharalis* in 1984 and 1985, respectively. Six infestation levels consisting of 0, 5, 10, 15, 20 and 30 larvae per plant were arranged in a randomized complete block (RCB) experimental design with seven replications during 1984. In 1985, nine treatments consisted of all possible combinations of an early (14 June) and a late (11 July) infestation level (0-0, 0-15, 0-30, 15-0, 15-15, 15-30, 30-0, 30-15, and 30-30) which were replicated six times in an RCB design. The first infestation of 1985 coincided with the same phenological growth stage (58.5 cm tall, 3 weeks prior to panicle appearance) of the 1984 study. The plant growth stage for the late infestation was 1 week prior to panicle appearance. Treatments were designed to provide a wide range of plant damage levels to supplement natural *D. saccharalis* infestations which were relatively low during both years of this study.

Laboratory-reared (wild individuals added to colony each growing season) first instar larvae were placed within
leafsheaths at the top, middle, and lower portion of stalks with a hand-operated applicator (Davis & Oswalt 1979). Calibration of larvae per plant was made by using the corn cob grit method described by Davis and Williams (1980). Larval survival data were collected by randomly selecting three plants per plot 15 days post-infestation. Four routine applications of the systemic insecticide monocrotophos (0.85 kg [AI] per ha) were used to maintain sugarcane borer-free plots. Insecticide applications during 1985 were also made late season to prevent naturally occurring D. saccharalis from moving into plots designated for early infestation evaluation. Chlordane (1.1 kg [AI] per ha) was applied on the soil surface to reduce D. saccharalis mortality from predatory arthropods. The plants were harvested during the third week of August. All plants were cut and weighed as whole and stripped (without leaves and seed heads) bundles. Estimates of percent bored internodes were determined from counts of total internodes as compared to number of bored internodes. Adult emergence was based on D. saccharalis moth exit holes converted to a per ha basis on plant stand.

Sugars were analyzed using the press method analysis of Tanimoto (1967) which provides measurements for Brix, Pol, and percent fiber. Brix is a percentage by weight of soluble solids in a pure sucrose solution (Meade & Chen 1977). The soluble solids can be translated into total sugars (all plant sugars) with a 0.7 reduction from the percent Brix.
value ([e.g., 19% soluble solids yields 18.3% total sugars] Ricaud & Arceneaux 1984). Pol estimates are used to provide the percent sucrose in juice (Meade & Chen 1977).

Damage level classes were created by grouping sweet sorghum samples into 5% D. saccharalis bored internode (i.e. 0-5, 6-10 ... 46-50) increments. Data were subjected to the General Linear Model (GLM) analyses (SAS Institute 1985) and differences between harmonic means were identified using Duncan's (1955) multiple range test. Variables which influence sugar yield or quality were analyzed using linear regressions on percent bored internodes for each year. Yield loss was approached from two perspectives: 1) regression of the yield of total sugars by percent bored internodes, and 2) creation of a new variable, yield loss, based on the subtraction of total sugars yield of each treatment from that found in monocrotophos treated control plots (zero percent bored internodes) within replications, and regressing yield loss by percent bored internodes.

Results

Overall larval survival at 15 d post infestation was 5.7% ± 0.09 (x ± SE) and 2.4 ± 0.30 for 1984 and 1985, respectively. As indicated in Table 1, larval survival for the late infestation (1985) was substantially lower. Thus, the majority of D. saccharalis damage for the 1985 study was attributed to the early infestation. Stalk damage by D. saccharalis ranged up to 50% for the two years. Stalk weight was found to be negatively correlated with
Table 1. Larval survival, adult emergence and yield of total sugars as affected by various early-late infestation levels of *D. saccharalis* larvae on sweet sorghum at St. Gabriel, La., in 1985.

<table>
<thead>
<tr>
<th>Infestation level (early - late)</th>
<th>Larvae per plant post-infestation</th>
<th>Adult emergence per plant</th>
<th>Total sugars (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 0</td>
<td>0.0 a</td>
<td>0.00 a</td>
<td>7,177.3 a</td>
</tr>
<tr>
<td>0 - 15</td>
<td>0.9 a</td>
<td>0.05 a</td>
<td>6,230.1 ab</td>
</tr>
<tr>
<td>0 - 30</td>
<td>0.8 a</td>
<td>0.07 a</td>
<td>5,633.9 b</td>
</tr>
<tr>
<td>15 - 0</td>
<td>2.0 b</td>
<td>0.41 b</td>
<td>6,249.1 ab</td>
</tr>
<tr>
<td>15 - 15</td>
<td>2.6 bc</td>
<td>0.47 bc</td>
<td>5,391.5 b</td>
</tr>
<tr>
<td>15 - 30</td>
<td>3.0 bc</td>
<td>0.42 b</td>
<td>5,710.6 b</td>
</tr>
<tr>
<td>30 - 0</td>
<td>3.6 d</td>
<td>0.48 bc</td>
<td>5,549.0 b</td>
</tr>
<tr>
<td>30 - 15</td>
<td>4.5 d</td>
<td>0.62 c</td>
<td>5,147.2 b</td>
</tr>
<tr>
<td>30 - 30</td>
<td>4.6 d</td>
<td>0.47 bc</td>
<td>4,946.7 b</td>
</tr>
</tbody>
</table>

Means in a column followed by the same letter are not significantly different at $P > 0.05$ according to Duncan's [1955] multiple range test.

*Number of larvae placed on plant on 14 June (early) and 11 July (late) 1985.*

*Number of live larvae after 15 days post-infestation; plot receiving early and late infestations were derived by combining total larvae found 15 d following infestation.*
D. saccharalis damage ($Y = 0.839 - 0.005x; Y =$ weight per stalk (kg), $x =$ percent bored internodes [$r^2 = 0.55, df = 7, F = 8.67, P < 0.0216$]). Brix values were significantly correlated with D. saccharalis damage [$r^2 = 0.96, df = 8, F = 192.33, P < 0.0001$] as shown in Fig. 1. Fiber estimates were shown to be positively correlated ($Y = 13.2 + 0.06x ; Y =$ percent fiber, $x =$ percent bored internodes [$r^2 = 0.46, df = 8, F = 6.84, P < 0.0309$]) with percent bored internodes in 1984. Differences were not detected in the 1985 data, and the disparity between intercepts and slopes of fiber for both years prevented combining data for valid estimations. A highly significant correlation existed for percent sucrose in juice and percent bored internodes ($Y = 16.84 - 0.073x; Y =$ percent sucrose juice, $x =$ percent bored internodes [$r^2 = 0.93, df = 106, F = 100.93, P < 0.0001$]) which indicated a yield-loss relationship of D. saccharalis damage to sucrose. However, a non-significant 2% drop in sucrose values was observed between the 0 to 10% bored internode classes (Table 2), and a 16% drop occurred when comparing nominal damage to that found at the 50% damage level. Yield loss contributions from lower Brix, higher fiber content, and reduced plant weight were 36.2, 14.5, and 49.3%, respectively.

A highly significant relationship was evidenced between total sugars yield and percent bored internodes for 1984 [$df = 7, F = 14.18, P < 0.0070$] and 1985 [$df = 8, F = 46.08, P < 0.0001$] as shown in Fig. 2. The intercepts for total sugars (kg/ha) yield for 1984 and 1985 were not similar; however,
Figure 1. Sweet sorghum yield loss and Brix reductions attributed to D. saccharalis larval damage at St. Gabriel, La. during 1984-85.
Table 2. Effects of *D. saccharalis* on yield and quality of total sugars for sweet sorghum at St. Gabriel, La., in 1984-85.

<table>
<thead>
<tr>
<th>Percent Internodes</th>
<th>Bored</th>
<th>n</th>
<th>Total sugars (kg/ha)</th>
<th>% Sucrose (Juice)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 5(^a)</td>
<td>25</td>
<td></td>
<td>8625.4 a</td>
<td>16.6 a</td>
</tr>
<tr>
<td>6 - 10</td>
<td>8</td>
<td></td>
<td>8523.2 a</td>
<td>16.2 abc</td>
</tr>
<tr>
<td>11 - 15</td>
<td>13</td>
<td></td>
<td>8110.4 ab</td>
<td>16.3 ab</td>
</tr>
<tr>
<td>16 - 20</td>
<td>17</td>
<td></td>
<td>8049.9 ab</td>
<td>15.6 abcd</td>
</tr>
<tr>
<td>21 - 25</td>
<td>16</td>
<td></td>
<td>7980.5 ab</td>
<td>15.4 abcd</td>
</tr>
<tr>
<td>26 - 30</td>
<td>11</td>
<td></td>
<td>5925.7 bc</td>
<td>14.5 cde</td>
</tr>
<tr>
<td>31 - 35</td>
<td>8</td>
<td></td>
<td>5469.1 c</td>
<td>14.7 bcde</td>
</tr>
<tr>
<td>36 - 40</td>
<td>5</td>
<td></td>
<td>5569.5 c</td>
<td>13.9 bcde</td>
</tr>
<tr>
<td>41 - 45</td>
<td>5</td>
<td></td>
<td>6181.2 bc</td>
<td>13.1 e</td>
</tr>
<tr>
<td>46 - 50</td>
<td>2</td>
<td></td>
<td>4740.3 c</td>
<td>14.0 de</td>
</tr>
</tbody>
</table>

Means in a column followed by the same letter are not significantly different (\(P > 0.05\); Duncan's [1955] multiple range test).

\(^a\)Fractional percentages are included in the following whole number.
Figure 2. Sweet sorghum yield of total sugars as affected by D. saccharalis bored internode internode damage at St. Gabriel, La., during 1984-85.
differences were not detected between slopes of these regression lines \[ t = 1.76, \text{df} = 9, P < 0.1162 \]. Yield loss calculated for 1984 \( Y = 0.0 + 46.2x \); \( Y \) = yield loss (kg), \( x \) = percent bored internodes \( r^2 = 0.66, \text{df} = 8, F = 15.64 P < 0.0042 \) and 1985 \( Y = 0.0 + 45.7x \) \( r^2 = 0.96, \text{df} = 9, F = 221.44, P < 0.0001 \) indicated that as \textit{D. saccharalis} damage increased, approximately 45 kg/ha depletion of total sugars could be expected for each additional percent of bored internodes. The yield loss correlation for both years combined was also highly significant \( r^2 = 0.95, \text{df} = 9, F = 172.14, P < 0.0001 \) as shown in Fig. 1). The effects of \textit{D. saccharalis} damage on sweet sorghum total sugars for 1984 and 1985 combined are shown in Table 2. When comparing the 0 and 50% bored internode classes, a yield loss of 45.0% was observed. A 515.0 kg/ha drop in yield was also observed between the 0 and 15% bored internode classes reflecting a 6.0% yield reduction.

**Discussion**

Larval survival for both years was similar to that found in corn (Flynn et al. 1984), and was sufficient to provide a wide range of \textit{D. saccharalis} damage levels. The late infestation treatment of 1985 had a substantially reduced larval survival, possibly due to increased predator build-up during late season, phenological differences associated with host plant suitability, or climatic conditions.
The analyses indicated that plant weight reductions were primarily responsible for most of the yield reduction which is similar to *D. saccharalis* damage found in sugarcane (Hensley 1971). Percent fiber increased with higher levels of bored internodes, which conforms to an anticipated increase in fiber due to *D. saccharalis* tunnelling damage and reduction of water uptake that would be reflected by lower juice levels. The degree of damage reflected in Brix reduction and increased fiber had approximately the same impact on total sugars yield. Percent sucrose in sweet sorghum juice also appears to be sensitive to changes in *D. saccharalis* bored internode levels (see Table 2).

Yield loss observed for both years individually or combined gave similar results in relation to the degree of *D. saccharalis* damage. An almost identical regression line was obtained for 1984 and 1985 when total sugars yield loss was regressed on percent bored internodes. This indicates that yield loss regression estimates are valid for calculating a damage level. The $r^2$ values for regression of yield loss were much greater than those for yield by percent bored internodes (Fig. 1 and 2). Overall yield for 1984 was greater than found in 1985 experiments (Fig. 2) which may have been attributed to characteristics of the different fields in the two studies, growing conditions, or greater plant stand for the 1984 study. Regardless of the level of yield for the 2 years, *D. saccharalis* effects on yield loss were found to be consistent.
Contract prices of 20.9 cents per kg of total sugars was set for the year 1986-87 by Agrifuels Refining Corp. of New Iberia, La. (J. E. Devillier, Louisiana Cooperative Extension Service, personal communication). The cost for one D. saccharalis insecticidal treatment of monocrotophos including aerial application is approximately $19.51 per ha. Thus, in relation to yield loss, approximately 93.3 kg of total sugars would justify 1 pesticide application treatment. A typical year under moderate to high D. saccharalis pressures would require a maximum of 3 applications (Reagan & Flynn 1986). Thus, the equivalent yield loss of 280.0 kg total sugars corresponds to 6.5% D. saccharalis bored internodes (43 kg/ha for each percent bored internode).

The non-linearity of points at low damage levels typically indicates that small numbers of pest insects have no effect on yield due to crop tolerance or compensation (Bardner & Fletcher 1974). In our study, the 11-15% bored internode class was the first to show an economic loss equal to the cost of insecticidal control. These losses were greater than twice the cost of estimated annual treatments, which indicates that the upper level of the lower class (10%) would serve as an appropriate determination for the economic injury level (see Table 2). This determination, additionally, corresponds favorably with the 6.5% level indicated by regression analyses. An economic threshold treatment decision at a 5% infestation of small larvae in leafsheaths is herein proposed to prevent economic injury.
The 5% infested plant economic threshold level is based also on a small plot screening trial which proved effective in maintaining *D. saccharalis* damage below the economic injury level (Fuller et al. 1987).
References Cited


CHAPTER II

Comparative Predation of the Sugarcane Borer (Lepidoptera: Pyralidae) on Sweet Sorghum and Sugarcane

The following chapter is modified from manuscript J87-281, which was accepted by the Journal of Economic Entomology and is currently in press.
Introduction

The composition of the arthropod predator complex in sugarcane, *Saccharum officinarum* L., has been investigated intensively (Negm & Hensley 1968, 1972, Reagan et al. 1972, Ali & Reagan 1985). These studies indicate the importance of arthropod predation in regulating populations of the sugarcane borer, *Diatraea saccharalis* (F.). The recent increase in sweet sorghum, *Sorghum bicolor* (L.) Moench, acreage in the sugarcane-growing region of Louisiana may have a substantial impact on sugarcane insect pest management (Reagan & Flynn 1986). Sugarcane is a perennial crop requiring minimal cultivation, but sweet sorghum, an annual crop, needs more conventional cultivation including intensive seedbed preparation.

Our study was undertaken to evaluate arthropod predation in sweet sorghum versus sugarcane, particularly as related to management of the key pest of sugarcane, *D. saccharalis*.

Materials and Methods

Field plots were located in Sharkey clay soils on the St. Gabriel Research Station and at the Gay Sugarcane Plantation in Iberville Parish, Louisiana. Sweet sorghum 'Wray' and sugarcane 'CP74-383' were planted on 50.3 m rows in adjacent plots (0.01 ha) with rows spaced 1.8 m apart. Sweet sorghum was double-drilled with a modified row spacing of approximately 0.9 m. Seeding rates of approximately 20 per meter provided plant stands of 5-8 plants (stalks) per meter.
of row (53,796 and 89,661 plants (stalks) per ha for 1986 and 1985, respectively). Plant cane (first-year sugarcane that was planted during the previous fall) stand counts were 74,717 plants per ha, and first-ratoon (regrowth of plants from the root system of the preceding yr) sugarcane was 119,256 plants per ha for 1985 and 1986, respectively.

A randomized complete block design with a 2 by 2 factorial arrangement of treatments at both locations was replicated four times. Treatments involved two factors: 1) with or without soil surface applied chlordane (1.1 kg [AI] per ha) for predator suppression and 2) sugarcane versus sweet sorghum. *Diatraea saccharalis* populations were allowed to develop throughout the season. Two sampling methods were used for this study: pitfall traps using two 473 ml jars (Greenslade 1964) per plot; and destructive sampling (dissection of 15 plants per plot each week). Pitfall traps were maintained for the entire season; thus provided continuous sampling for arthropods associated with the soil surface. Estimates of arthropod populations associated with the canopy were obtained from destructive sampling. All field-collected specimens were classified at least to family.

To measure various parameters associated with the yield of total sugars, ten 10-stalk bundles were harvested at random from each plot. Plants were cut whole and stripped (without leaves and seed heads), and weights were recorded. Each stalk was carefully examined for *D. saccharalis* larval
entrance and adult emergence holes. Percent bored internodes were determined from counts of total internodes, compared with the number of internodes bored. Adult emergence was based on total *D. saccharalis* moth exit holes per plant, translated to a per ha basis using plant stand (number of plant per ha within plots). Larval survival after entry was calculated using the number of *D. saccharalis* moth exit holes divided by the number of entry holes. This provides a liberal estimate of survival because a larva can re-enter a stalk at another position. However, most dissection samples indicated that only one entrance hole was associated with a single *D. saccharalis* larva inside the stalk.

Parameters associated with sugar yield were measured for plants after damage data were recorded. In this study, total sugars included all fermentable plant sugars (e.g., sucrose, fructose). Sugars were analyzed using the press method of Tanimoto (1967) which provides measurements for Brix and percent fiber. Brix is a percentage by weight of soluble solids in a pure sucrose solution (Meade & Chen 1977). These soluble solids can be translated into total sugars with a 0.7 reduction from the percent Brix value ([e.g., 19% soluble solids yields 18.3% total sugars] Ricaud & Arceneaux 1984). Data were subjected to the General Linear Model (GLM) analysis procedure (SAS Institute 1985); differences between means were identified using the F statistic.
Results

Canopy Fauna

The total number of predators per ha was significantly greater in sugarcane than for sweet sorghum during both years (Tables 1, 2). This difference was approximately 4- and 16-fold for plant and first-ratoon sugarcane, compared with sweet sorghum. This pattern was most indicative of red imported fire ant, *Solenopsis invicta* Buren, populations found in the canopy. Canopy-dwelling carabids collected were almost exclusively *Leptotrachelus dorsalis* (F.). Significantly greater populations of carabid larvae were found in sweet sorghum than in either plant or first-ratoon sugarcane. Lacewings (Chrysopidae) and minute pirate bugs, *Orius* spp., (Anthocoridae) were the only other predators found in the canopy that were not represented in pitfall trap samples.

Soil Surface Fauna

The mean number of arthropod predators found in biweekly pitfall trap samples during 1985 were significantly \[F = 24.43; \text{df} = 1, 148; P < 0.0001\] greater in sweet sorghum when compared with the plant cane crop of sugarcane (Table 3). Although significant differences were not detected in the first-ratoon crop of sugarcane in 1986, there was a 37.5% greater abundance of predators in sweet sorghum.

The same species of arthropod predators associated with the soil surface were represented during both years. The species composition did not differ from those previously

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
Table 1. Mean number x 10^3 per week of canopy associated arthropods per ha in sweet sorghum and adjacent plant cane, collected from weekly destructive samples, Iberville Parish, Louisiana in 1985.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Treatment</th>
<th>Total predators</th>
<th>Solenopsis invicta</th>
<th>Carabidae</th>
<th>Orius spp.</th>
<th>Coccinellidae</th>
<th>Araneidae</th>
<th>Chrysopidae b</th>
<th>Diatraea saccharalis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sweet sorghum</td>
<td>No chlordane</td>
<td>399.7 a</td>
<td>386.8 a</td>
<td>5.4 a</td>
<td>1.1 a</td>
<td>0.0 a</td>
<td>0.0 a</td>
<td>6.5 a</td>
<td>0.0 a</td>
</tr>
<tr>
<td></td>
<td>Chlordane</td>
<td>48.6 b</td>
<td>9.7 b</td>
<td>6.3 a</td>
<td>4.3 a</td>
<td>0.0 a</td>
<td>21.6 a</td>
<td>6.5 a</td>
<td>0.0 a</td>
</tr>
<tr>
<td>Sugarcane</td>
<td>No chlordane</td>
<td>89.9 a</td>
<td>70.0 a</td>
<td>6.4 a</td>
<td>1.1 a</td>
<td>7.3 b</td>
<td>0.0 a</td>
<td>2.7 a</td>
<td>1.8 a</td>
</tr>
<tr>
<td></td>
<td>Chlordane</td>
<td>50.8 a</td>
<td>0.0 b</td>
<td>3.6 a</td>
<td>8.2 a</td>
<td>20.0 a</td>
<td>6.4 a</td>
<td>5.4 a</td>
<td>7.3 a</td>
</tr>
</tbody>
</table>

Means in columns within crops followed by the same letter are not significantly different (P > 0.05 using the F statistic; NS = P > 0.05, * = P < 0.05, ** = P < 0.01.

Crop effects ** ** NS ** ** NS NS NS **
Chlordane effects ** ** NS NS * NS NS NS **
Crop x chlordane ** ** NS NS * NS NS NS **

Sampling period: sweet sorghum 8 July - 19 September; sugarcane 8 July - 7 October.

Less than 1% of the lacewings included within the Chrysopidae data were Hemerobiidae.
Table 2. Mean number x 10^2 per week of canopy associated arthropods per ha in sweet sorghum and adjacent first-ratoon sugarcane, collected from weekly destructive samples, Iberville Parish, Louisiana in 1986\(^a\).

<table>
<thead>
<tr>
<th>Crop</th>
<th>Treatment</th>
<th>Total predators</th>
<th>Solenopsis invicta</th>
<th>Other Formicidae</th>
<th>Carabidae</th>
<th>Orius spp.</th>
<th>Coccinellidae</th>
<th>Araneae</th>
<th>Demaptera(^b)</th>
<th>Diatraea saccharalis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sugarcane</td>
<td>No chlordane</td>
<td>981.5 a</td>
<td>858.0 a</td>
<td>110.7 a</td>
<td>0.0 a</td>
<td>0.5 a</td>
<td>0.9 a</td>
<td>2.8 a</td>
<td>8.4 a</td>
<td>71.5 b</td>
</tr>
<tr>
<td></td>
<td>Chlordane</td>
<td>158.8 b</td>
<td>4.2 b</td>
<td>141.3 a</td>
<td>0.0 a</td>
<td>4.3 a</td>
<td>0.0 a</td>
<td>2.0 a</td>
<td>2.4 a</td>
<td>4.7 a</td>
</tr>
<tr>
<td>Sweet sorghum</td>
<td>No chlordane</td>
<td>63.0 a</td>
<td>50.6 a</td>
<td>0.8 a</td>
<td>0.4 a</td>
<td>3.6 a</td>
<td>4.8 a</td>
<td>0.8 b</td>
<td>2.0 a</td>
<td>0.0 a</td>
</tr>
<tr>
<td></td>
<td>Chlordane</td>
<td>23.1 b</td>
<td>0.0 b</td>
<td>0.0 a</td>
<td>0.8 a</td>
<td>8.0 a</td>
<td>3.6 a</td>
<td>8.4 a</td>
<td>2.4 a</td>
<td>0.0 a</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Statistical comparisons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crop effects</td>
</tr>
<tr>
<td>Chlordane effects</td>
</tr>
<tr>
<td>Crop x chlordane</td>
</tr>
</tbody>
</table>

Means in columns within crops followed by the same letter are not significantly different (\(P > 0.05\) using the F statistic; \(NS = P > 0.05\), \(* = P < 0.05\), \(** = P < 0.01\).

\(^a\) Sampling periods: sweet sorghum 17 July - 9 September; sugarcane 17 July - 2 October.

\(^b\) Including Forficulidae, Labiduridae, Labiidae.
Table 3. Mean number per pitfall trap of arthropods associated with the soil surface associated arthropods in sweet sorghum and adjacent plant cane, collected every two weeks, Iberville Parish, Louisiana in 1985^a^.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Treatment</th>
<th>Total predators</th>
<th>Solenopsis invicta</th>
<th>Other Formicidae</th>
<th>Cicindelidae</th>
<th>Carabidae</th>
<th>Staphylinidae</th>
<th>Dermaptera^b^</th>
<th>Gryllidae</th>
<th>Araneae</th>
<th>Coleoptera</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sugarcane</td>
<td>No chlordane</td>
<td>23.8 a</td>
<td>14.9 a</td>
<td>0.9 a</td>
<td>0.3 a</td>
<td>0.7 a</td>
<td>0.7 a</td>
<td>0.6 a</td>
<td>17.9 a</td>
<td>5.6 a</td>
<td>0.1 a</td>
</tr>
<tr>
<td>Chlordane</td>
<td>8.0 b</td>
<td>1.9 b</td>
<td>0.3 a</td>
<td>0.4 a</td>
<td>1.9 a</td>
<td>0.3 a</td>
<td>0.3 a</td>
<td>14.2 a</td>
<td>2.2 b</td>
<td>0.7 a</td>
<td></td>
</tr>
<tr>
<td>Sweet sorghum</td>
<td>No chlordane</td>
<td>53.6 a</td>
<td>29.9 a</td>
<td>0.2 a</td>
<td>8.8 a</td>
<td>1.9 b</td>
<td>1.1 a</td>
<td>0.1 a</td>
<td>17.9 a</td>
<td>10.6 a</td>
<td>0.9 a</td>
</tr>
<tr>
<td>Chlordane</td>
<td>26.2 b</td>
<td>3.3 b</td>
<td>0.0 a</td>
<td>8.9 a</td>
<td>8.4 a</td>
<td>0.8 a</td>
<td>0.0 a</td>
<td>19.1 a</td>
<td>4.0 b</td>
<td>0.7 a</td>
<td></td>
</tr>
</tbody>
</table>

**Statistical comparisons**

| Crop effects | ** | * | NS | ** | ** | NS | NS | NS | ** | NS |
| Chlordane effects | ** | ** | NS | NS | ** | NS | NS | NS | ** | NS |
| Crop x chlordane | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |

Means in columns within crops followed by the same letter are not significantly different (P > 0.05 using the F statistic; NS = P > 0.05, * = P < 0.05, and ** = P < 0.01.

^a^Sampling periods: sweet sorghum 15 July - 18 September; sugarcane 15 July - 10 October.

^b^Including Forficulidae, Labiduridae and Labiidae.
reported (Negm & Hensley 1968, 1972, Reagan et al. 1972, Ali & Reagan 1985). The red imported fire ant was the dominant predator collected in pitfall traps in both crops. Carabids and Orius spp. were the only predators of significantly greater abundance in plots where predators were suppressed with chlordane. Carabids, cicindelids, and Araneae were also significantly more abundant in sweet sorghum during both years. Data for Gryllids were considered (Tables 3 and 4) because crickets serve as an alternate food source for major predator groups when D. saccharalis populations are at low levels in the sugarcane/sweet sorghum agroecosystem (Reagan 1986). The lycosids (wolf spiders) composed 51.8 and 80.2% of the were more abundant in plant cane (58.9%) than in first-ratoon sugarcane (39.4%) (see Appendix A). However, clubionids (45.5%) were the most common family of spiders found in first-ratoon sugarcane.

**Predation**

Larval D. saccharalis populations were 44.8 and 60% greater in predator suppression plots of sweet sorghum for 1985 and 1986, respectively. An increases in the number of D. saccharalis larvae in plant cane (25.0%) and first-ratoon sugarcane (46.2%) was found in plots treated with chlordane. Percent damage associated with internodes bored by D. saccharalis and larval survival after stalk entry is shown in Table 5. Diatraea saccharalis populations were lower during 1985 than 1986 season due to preceding harsh winter conditions. Thus, increased damage to sweet sorghum
and sugarcane occurred in 1986 compared with that experienced in 1985. Sugarcane sustained significantly (F = 51.64; df = 1, 54; P < 0.0001 in 1985, and F = 18.86; df = 1, 9; P < 0.0019 in 1986) higher levels of damage when compared with sweet sorghum. Higher damage levels paralleled greater D. saccharalis larval populations in sugarcane (Tables 1, 2, 5). Larval survival after stalk entry was significantly (F = 57.89; df = 1, 9; P < 0.0001 in 1985, and F = 26.02; df = 1, 54; P < 0.0001 in 1986) greater in sweet sorghum than that observed in sugarcane. Differences in D. saccharalis moth production in sugarcane and sweet sorghum plots with and without predator suppression were not detected in 1985 (Table 5). Sugarcane had significantly (F = 11.01; df = 1, 28; P < 0.0025) greater moth production than sweet sorghum in 1986.

During 1985, differences in total sugars produced in plots with and without predator suppression were not detected in plant cane (10,960.1 and 11,694.5 kg/ha) or sweet sorghum (8,116.9 and 8,667.8 kg/ha), respectively. However, plots with predators had a 6.3 and 6.4% greater yield for plant cane and sweet sorghum, respectively, in 1985.

First ratoon sugarcane plots with and without predator suppression produced 8,745.5 and 10,745.4 kg/ha of total sugars, respectively; these levels represent a significantly [F = 2.60; df = 1, 23; P < 0.0001] greater yield for plots with predators. A significant [F = 33.40; df = 1, 28; P < 0.0027] increase in yield of total sugars also was found in
Table 4. Mean number per pitfall trap of arthropods associated with the soil surface in sweet sorghum and adjacent first-ratoon sugarcane, collected every two weeks, Iberville Parish, Louisiana in 1986a.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Treatment</th>
<th>Total predators</th>
<th>Solenopsis invicta</th>
<th>Cicindelidae</th>
<th>Carabidae</th>
<th>Staphylinidae</th>
<th>Dermaptera b</th>
<th>Gryllidae</th>
<th>Araneidae</th>
<th>Coccinellidae</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sugarcane</td>
<td>No chlordane</td>
<td>38.0 a</td>
<td>34.1 a</td>
<td>0.2 a</td>
<td>0.1 a</td>
<td>0.3 a</td>
<td>0.1 a</td>
<td>10.4 a</td>
<td>3.3 a</td>
<td>0.1 a</td>
</tr>
<tr>
<td></td>
<td>Chlordane</td>
<td>3.6 b</td>
<td>2.0 b</td>
<td>0.1 a</td>
<td>0.2 a</td>
<td>0.3 a</td>
<td>0.0 a</td>
<td>10.7 a</td>
<td>0.8 b</td>
<td>0.3 a</td>
</tr>
<tr>
<td>Sweet sorghum</td>
<td>No chlordane</td>
<td>47.4 a</td>
<td>32.9 a</td>
<td>5.0 a</td>
<td>0.3 b</td>
<td>1.4 a</td>
<td>0.1 a</td>
<td>12.6 a</td>
<td>7.6 a</td>
<td>0.1 b</td>
</tr>
<tr>
<td></td>
<td>Chlordane</td>
<td>18.6 b</td>
<td>4.9 b</td>
<td>6.4 a</td>
<td>2.2 a</td>
<td>0.5 b</td>
<td>0.2 a</td>
<td>15.1 a</td>
<td>3.8 b</td>
<td>0.5 a</td>
</tr>
</tbody>
</table>

Statistical comparisons:

- Crop effects: NS NS ** ** * NS NS ** NS
- Chlordane effects: ** ** NS ** * NS NS ** *
- Crop x chlordane: NS NS NS ** * NS NS NS NS

Means in columns within crops followed by the same letter are not significantly different (P > 0.05 using the F statistic; NS = P > 0.05, * = P < 0.05, and ** = P < 0.01).

*Sampling periods: sweet sorghum 17 July – 23 September; sugarcane 17 July – 2 October.

bIncluding Forficulidae, Labiduridae and Labiidae.
Table 5. Percent *D. saccharalis* bored internodes, larval survival and total moth emergence determined from harvest records for sweet sorghum and sugarcane, Iberville Parish, Louisiana in 1985-1986.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Treatment</th>
<th>Bored internodes (%)</th>
<th>Larval survival after entry (%)</th>
<th>Adult emergence (thousands/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1985</td>
<td>1986</td>
<td>1985</td>
<td>1986</td>
</tr>
<tr>
<td>Sugarcane</td>
<td>No chlordane</td>
<td>22.2 b 10.4 b</td>
<td>4.9 a 1.7 b</td>
<td>10.3 a 21.6 b</td>
</tr>
<tr>
<td></td>
<td>Chlordane</td>
<td>28.3 a 35.6 a</td>
<td>3.8 a 10.4 a</td>
<td>18.1 a 43.1 a</td>
</tr>
<tr>
<td>Sweet sorghum</td>
<td>No chlordane</td>
<td>4.0 a 8.6 b</td>
<td>22.2 b 10.8 a</td>
<td>9.3 a 11.2 b</td>
</tr>
<tr>
<td></td>
<td>Chlordane</td>
<td>6.9 a 16.0 a</td>
<td>24.1 a 13.8 a</td>
<td>13.0 a 25.3 a</td>
</tr>
</tbody>
</table>

Means in columns within crops followed by the same letter are not significantly different (\( P > 0.05 \) using the *F* statistic.)
plots of sweet sorghum with predators (5,977.9 kg/ha) when compared with predator suppression plots (4,641.2 kg/ha). Yield increases in plots with predators was 18.6 and 22.4% for first-ratoon sugarcane and sweet sorghum, respectively in 1986.

Discussion

The 4- and 16-fold greater predator populations in plant and ratoon sugarcane, compared with the sweet sorghum fauna, are related to cultivation practices. Plant cane is planted in the fall, permitting the increase of predator populations from October until the next spring. During the spring of 1985, seedbed preparation for the first planting of sweet sorghum disturbed the field's arthropod fauna. Cultivation practices destroy red imported fire ant mounds, increase mortality, reduce food supply (Ali et al. 1984) and stimulate colony relocation and nest rebuilding in stable habitats provided by undisturbed field margins. These practices would account for the 4-fold difference for the two crops during 1985. This difference in predator populations increased to 16-fold due to minimal cultivation and perennial nature of first-ratoon sugarcane while the annual crop of sweet sorghum again received conventional tillage in 1986 that caused greater habitat disruption. Thus, predator populations (especially those of S. invicta) were permitted to increase for over two years in first-ratoon sugarcane while sweet sorghum cultivation practices adversely
affected predators.

The significantly larger number of arthropods associated with the soil surface in sweet sorghum, compared with those in sugarcane, may be misleading. Numbers of predators did not differ greatly in magnitude between the two crops. Trap avoidance was observed for *S. invicta* foragers; they constructed trails up to the edge of the pitfall trap and then altered direction to evade the trap. This avoidance behavior was observed in both crops and all treatments. However, valid comparisons with pitfall traps are possible, although canopy estimates provided a more accurate measure of the *S. invicta* populations in this study.

The sugarcane borer was not as abundant in sweet sorghum during either year of this study. This is not related to resistance since both crop cultivars are susceptible to this pest and larval survival after stalk entry was significantly greater in sweet sorghum. Two factors may be affecting these differences: 1) *D. saccharalis* moths are poor fliers and usually move into plant cane fields from nearby ratoon sugarcane or from seed-cane which is infested at the time of planting; and 2) *D. saccharalis* oviposition preference may differ between the two crops. Both plant cane and sweet sorghum would have been infested from nearby ratoon sugarcane. Early season *D. saccharalis* moth populations emerge from overwintering larvae at the base and subsurface portions of sugarcane stalks remaining after harvest. Thus, first-ratoon sugarcane would have a greater
number of moths emerging, while cultivation practices for sweet sorghum would have destroyed any crop residue from the previous season. Although host habitat finding for D. saccharalis has not been defined, it appears that adult emergence within sugarcane and its poor flight ability may delay movement into sweet sorghum.

Moth emergence between the two crops did not differ in 1985 due to the greater number of larvae surviving in sweet sorghum. Thus, equal infestation in both crops would probably lead to greater numbers of D. saccharalis moths from sweet sorghum. Dramatic reductions in moth production from natural control by predators was especially evident in 1986. Predators provided 3- and 2-fold reduction in bored internodes in plots without predator suppression for sugarcane and sweet sorghum in 1986. The greater reduction in damage for sugarcane can be attributed to its increased predator population.

Natural control provided by the predator complex in sweet sorghum is extremely important. Plots without predator suppression did not exceed the 10% bored internode economic injury level (Fuller et al. 1988). However, plant cane damage in plots with predators did exceed the 10-14% bored internode economic injury level. Increased cultivation practices in plant cane, compared with ratoon sugarcane, also resulted in the disruption of the predatory arthropod fauna. White (1980) found increased predator population in ratoon crops of sugarcane. Thus, more damage
should be expected in plant cane compared with first-ratoon.

Differences in yield for plant cane and sweet sorghum were not detected in plots with and without predator suppression. This, in part, is caused by environmental disruption and the lower D. saccharalis pest populations experienced in 1985. The dramatic increase in yield between first-ratoon sugarcane and sweet sorghum in 1986 better illustrates the potential that predators provide as part of an integrated pest management program. Thus, control with insecticides and cultivation practices that adversely affect the predatory fauna should be avoided by using pesticides with less impact on beneficial organisms and increasing habitat stability (e.g., reduced tillage practices, undisturbed field margins).
References Cited


CHAPTER III

Plant Stand Density Effect on the Sugarcane Borer (Lepidoptera: Pyralidae) in Sweet Sorghum

The following chapter is modified from a manuscript which has been submitted to the Journal of Economic Entomology.

42

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
Introduction

Worldwide production of sweet sorghum, *Sorghum bicolor* (L.) Moench, production has increased in recent years because of its utilization in making fuel alcohol. This crop is highly susceptible to attack by the sugarcane borer, *Diatraea saccharalis* (F.), the key pest of sugarcane in the western hemisphere (Reagan & Flynn 1986, Fuller & Reagan 1988). Commercial plantings of sweet sorghum have been limited to the 'Wray' variety in Louisiana. In sugarcane, *D. saccharalis* mortality factors include leafsheath appression, rind hardness, and high fiber content (Coburn & Hensley 1972, Martin et al. 1975, Reagan & Martin 1987). Research involving sugarcane borer resistance in sweet sorghum has been limited to a two trial study conducted in San Paulo, Brazil (Lara & Perussi 1984). In the first trial, a significant (*r* = 0.52, *P* < 0.05) positive correlation was found between percent infestation and diameter at the median internode of sweet sorghum plants. A non-significant positive relationship was observed in the second trial. Lara & Perussi (1984) declined to speculate on the resistance mechanism. It is assumed that the decreased level of infestation with smaller stalk diameter may have been related to increased fiber content which occurs as stalk barrel size decreases. High fiber content in sugarcane generally causes greater *D. saccharalis* larval mortality (Mathes & Charpentier 1962). Stalk barrel size can be manipulated by changing planting densities, with
higher densities resulting in narrower stalk barrel size. Therefore, the objective of this study was to compare planting densities of sweet sorghum to determine if the resultant narrow stalk barrel size and associated increase in fiber could serve as a potential cultural control in sweet sorghum insect pest management.

Materials and Methods
Sweet sorghum 'Wray' was planted in four row plots with 0.91 m spacing (13.72m long, 0.005ha plots) on 2 June 1984 and 15 June 1986 at the St. Gabriel Research Station, Iberville Parish, Louisiana. A randomized complete block with a split-split plot experimental design was used with five and four replications for 1984 and 1986, respectively. Plots designed to have D. saccharalis suppressed populations were treated with monocrotophos (Azodrin - 0.85 kg [AI] per ha) and untreated plots represented the main plot effects. Sub-plot factors were plant stand density and sampling date, respectively. Average plant stand treatments were 3.6 (39,353 per ha), 5.3 (59,936 per ha), 8.6 (94,016 per ha) and 14.3 (156,320 ha) plants per meter of row. Stands were established by hand thinning higher plant populations to the desired density levels to insure even spacing within treatments. A Commerce silt loam soil type (fine-silty, mixed, nonacid, thermic, aeric fluvaquents [Smith et al. 1983]) characterized all plots during both years.
In plots with *D. saccharalis* suppression, infestation samples were taken to determine when monocrotophos applications were necessary. Five plants per plot from the two outside rows were examined for *D. saccharalis* larval infestations and beneficials arthropods with data collected on three dates during 1984 and weekly during 1986. The small sample size was necessary to maintain treatment densities throughout the season. Equal number of stalks sampled across density treatments resulted in a larger percentage of plants per area sampled in the lower planting densities. Therefore, *D. saccharalis* larval estimates and total predator counts were converted to number per m². Individual predator species abundance is not reported due to the small plot dimensions and sample size. Stalk height and diameter measurements were recorded on 14 July, 2 August, and 10 October. The two center rows of each plot were cut and weighed at harvest. Leaves from these plants were removed and internodes examined for *D. saccharalis* larval entrance or moth exit holes. Percent bored internodes were calculated by division of the number of *D. saccharalis* borer internodes by the total number of internodes. Sugarcane borer adult emergence levels were determined by converting moth exit holes into per ha units. Two 25-stalk bundles per plot were randomly chosen for sugar analysis. Diameter of the third internode from the base of each stalk was recorded. Juice extraction and percent fiber estimates were conducted using the press method as described by Tanimoto.
(1967). Total sugars (all fermentable sugars) estimates were derived from soluble solid measurements (Brix) according to methods by Ricaud & Arceneaux (1984). Arcsin square-root transformations were performed on percentage values. Data were subjected to the General Linear Model Analysis (SAS Institute 1985) and mean separations were by the $F$ test or Duncan's (Duncan 1955) multiple range test where appropriate.

**Results**

Analyses of *D. saccharalis* larval population estimates indicated significantly [$F = 2.96; df = 3, 48; P < 0.0417$] greater numbers were present as sweet sorghum planting density increased (Fig. 1). This observation was supported by similar levels of percent bored internode damage among density treatments (Table 1). Greater larval populations would have been essential to cause equal injury as plant stand density increased. Early (14 July) season plant heights were greater in plots with increased plant stand densities (Fig. 2). However, plant height was more variable on 2 August in relation to plant stand. Reversed trends between increase height and greater plant stands were found on 10 October which reflects reduced internode length from damage caused by increased *D. saccharalis* larval populations. Early height differences probably caused greater oviposition by *D. saccharalis* moths in plots with greater plant height. Monocrotophos applications were effective in reducing *D. saccharalis* damage (Table 1); however, a mean of 10.9% bored
Figure 1. Mean weekly *D. saccharalis* larval infestation estimates for differing planting densities of sweet sorghum at St. Gabriel, La., 1984 and 1986.
Table 1. Sweet sorghum planting stand effects on *D. saccharalis* larval survival, damage indices, and yield of total sugars at St. Gabriel, La., in 1984 and 1986.

<table>
<thead>
<tr>
<th>Whole plot treatment</th>
<th>Planting density (plants/m)</th>
<th>Stalk diameter (cm)</th>
<th>Internodes bored (%)</th>
<th>Fiber (%)</th>
<th>Larval survival (%)</th>
<th><em>D. saccharalis</em> moth emergence (10⁵/ha)</th>
<th>Total sugars (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Azodrin</td>
<td>14.3</td>
<td>1.56 d</td>
<td>3.4 b</td>
<td>11.4 ab</td>
<td>3.6 b</td>
<td>4.2 b</td>
<td>8,564.9 a</td>
</tr>
<tr>
<td></td>
<td>8.6</td>
<td>1.86 c</td>
<td>4.0 b</td>
<td>11.6 a</td>
<td>11.8 ab</td>
<td>8.8 ab</td>
<td>6,139.7 cd</td>
</tr>
<tr>
<td></td>
<td>5.3</td>
<td>2.26 b</td>
<td>3.3 b</td>
<td>10.8 bc</td>
<td>27.4 a</td>
<td>5.0 b</td>
<td>5,620.0 d</td>
</tr>
<tr>
<td></td>
<td>3.6</td>
<td>2.62 a</td>
<td>3.2 b</td>
<td>10.4 c</td>
<td>12.7 ab</td>
<td>2.9 b</td>
<td>4,337.5 e</td>
</tr>
<tr>
<td>No azodrin</td>
<td>14.3</td>
<td>1.58 d</td>
<td>10.5 a</td>
<td>12.1 a</td>
<td>9.4 ab</td>
<td>17.7 a</td>
<td>7,340.6 b</td>
</tr>
<tr>
<td></td>
<td>8.6</td>
<td>1.92 c</td>
<td>10.9 a</td>
<td>11.4 ab</td>
<td>10.7 ab</td>
<td>17.4 a</td>
<td>6,734.6 bc</td>
</tr>
<tr>
<td></td>
<td>5.3</td>
<td>2.25 b</td>
<td>8.8 a</td>
<td>10.2 c</td>
<td>11.6 ab</td>
<td>9.3 ab</td>
<td>5,537.4 d</td>
</tr>
<tr>
<td></td>
<td>3.6</td>
<td>2.53 a</td>
<td>9.7 a</td>
<td>10.8 bc</td>
<td>11.0 ab</td>
<td>8.0 ab</td>
<td>4,045.1 e</td>
</tr>
</tbody>
</table>

Mean separation within columns followed by the same letter are not significantly different at \( P > 0.05 \) using Duncan's (Duncan 1955) multiple range tests with the weighted whole-subplot interaction term.

Diameter was measured in the middle of the third internode from the base of the plant.

Based on *D. saccharalis* survival after entry into sweet sorghum stalks.

Insecticidal treatment applied to suppress *D. saccharalis* populations.
Figure 2. Mean sweet sorghum plant height (cm) in relation to sweet sorghum planting density at St. Gabriel, La., 1984.
internodes represented the greatest damage incurred. Thus, differences in damage levels between treated and untreated plots were not sufficient to cause detectable total sugars yield differences, and greater yield was found only in the highest planting density (see Table 1). Altering planting densities provided the desired levels of stalk barrel sizes and as expected plant fiber content was greater in plants with smaller diameters. However, resulting *D. saccharalis* larval survival was approximately the same for all planting densities, and differences were not detected in *D. saccharalis* moth emergence levels despite a 2-fold greater number of moths emerging from the highest density plots when compared with the 3.6 plants/m treatment.

Sample size inhibited reliable estimates of beneficial predators. Thus, differences in total predators were not detected between plant stands.

**Discussion**

Sugarcane borer populations were not deleteriously affected by decreased barrel size and associated higher fiber levels in sweet sorghum. Estimates of *D. saccharalis* larval populations and moth emergence levels were highest in untreated (no azodrin) plots with the greatest planting density. However, this increase in *D. saccharalis* larvae from plots with higher plant densities is probably not an indication that increasing stands would lead to greater pest problems. Moreover, several factors could have played an important role in the increased larval populations in the
higher plant stands (e.g., a preference for *D. saccharalis* moth oviposition in plots containing taller plants; moth preference for more dense planting stands due to decreased light penetration of the canopy; or greater predation in plots which contained fewer plants for individual predators to forage upon which could result in reduced searching time and increased predator efficiency). Previous predation studies in sweet sorghum have indicated the importance of predators in the natural control of this key pest (Fuller & Reagan 1988).

Because planting density and *D. saccharalis* population dynamics are not strongly related, other agronomic assessments are of greater importance in determining appropriate plant stands. Significantly greater yields obtained from the highest planting density must be weighed against lodging problems. Although minor late season lodging occurred in this study, hand harvesting eliminated any yield loss attributed to lodging. In contrast, mechanical harvesting would be essential for farmers, and lodging could be a major consideration. Lodging is more probable in plots with higher densities, and was greatest in some of the highest density plots. Sweet sorghum plantings for concurrent studies used 5 to 8 plants per meter of row and follow current farming practices (Fuller et al. 1988).

Renewed interest in sweet sorghum as a feeder stock for ethanol production will require additional studies to determine effective cultural control practices. However, higher
fiber content in 'Wray' sweet sorghum as a result of increasing plant stand should not be considered as a cultural control strategy and other resistance mechanisms including rind hardness, and leafsheath appression should be considered in any future breeding programs for D. saccharalis resistance in sweet sorghum.
References Cited


SUMMARY

This research provides essential knowledge to adapt current sugarcane insect pest management strategies that may arise relative to the introduction of sweet sorghum into the south Louisiana sugarcane growing region. The development of an economic injury level of 10% *D. saccharalis* bored internodes will allow farmers to spray insecticides at the proposed economic threshold (leafsheaths of 5% of the stalks are infested with small *D. saccharalis* larvae). Thus, sweet sorghum producers will be treating when necessary, rather than on a schedule. This is the key principle of economic threshold concept. It will provide greater cost efficiency and reduce insecticide applications. Therefore, the utilization of this economic threshold will decrease excessive pesticide usage which causes environmental contamination, as well as reduce selection pressures that hasten insecticidal resistance. Insecticidal control nevertheless is an essential tool in combatting the sugarcane borer. The insecticide screening study (Appendix B) assisted efforts in choosing the most efficacious pesticide. Also, this study aided in testing the proposed economic threshold.

Predatory faunal composition and relative population estimates gave supportive evidence of the tremendous value that several predator taxa have in the natural control of the sugarcane borer in both sugarcane and sweet sorghum. The red imported fire ant is by far the most abundant and
effective predator in both crop systems. The stability of the perennial sugarcane tillage system in comparison with that found in sweet sorghum was probably the key factor in reduced *S. invicta* populations. Sweet sorghum had significantly greater populations of tiger beetles (Cicindellidae), predacious ground beetles (Carabidae), spiders (Araneae), lacewings (Chrysopidae) and minute pirate bugs (Anthocoridae). Reduced *S. invicta* populations were primarily responsible for the 4- and 16-fold fewer total predator estimates in sweet sorghum when compared with plant and first-ratoon sugarcane, respectively.

Sugarcane borer populations in sweet sorghum were less than those of sugarcane in both years. Under heavy *D. saccharalis* population pressures in 1986, predation accounted for a 3-fold reduction in *D. saccharalis* damage in sugarcane. Similarly, a 2-fold reduction of damage was found in sweet sorghum in plots without predator suppression. Although *D. saccharalis* infestations were not as great in sweet sorghum, larval survival in plots with predator suppression was much increased when compared to that found in sugarcane. This indicates that smaller early season *D. saccharalis* populations could build-up in greater numbers in sweet sorghum than in sugarcane. Although, *D. saccharalis* moth emergence was much lower in sweet sorghum, predation was shown to reduce the number of moths in both crops by 50%.
Increased larval survival after tunnelling inside sweet sorghum stalks is the only major factor which separates this crop from the tactics that would be used for growing a highly susceptible variety of sugarcane. Due to this problem, careful scouting and treatment at the economic injury level will alleviate pest outbreaks and prevent massive dispersion into adjacent sugarcane.

The planting density studies revealed that high fiber in 'Wray' sweet sorghum is not detrimental to the survival of *D. saccharalis* larvae. Although, barrel size and fiber content can be manipulated by adjusting seeding rates to provide greater sweet sorghum planting stands, no relationship to increased mortality in *D. saccharalis* populations was detected. Thus, plant stand manipulation was determined not to be an effective cultural control practice; and further research is necessary to discern other *D. saccharalis* resistance mechanisms (e.g. rind hardness, leafsheath appression).

This research provides a sound perspective of *D. saccharalis* bionomics on sweet sorghum. Knowledge provided will assist in the implementation of insect pest management strategies and tactics for sweet sorghum in the sugarcane growing region of south Louisiana.
LIST OF REFERENCES


APPENDICES
APPENDIX A

Soil surface associated spiders of sweet sorghum and adjacent sugarcane
Table 1. Mean number of soil surface associated spiders in sweet sorghum and adjacent plant cane, collected from biweekly pitfall trap samples, Iberville, La., in 1985\(^a\).

<table>
<thead>
<tr>
<th>Crop</th>
<th>Treatment</th>
<th>Lycosidae</th>
<th>Clubionidae</th>
<th>Nesticidae</th>
<th>Linyphiidae</th>
<th>Therididae</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sugarcane</td>
<td>No chlordane</td>
<td>3.3 a</td>
<td>0.3 a</td>
<td>0.1 a</td>
<td>0.7 a</td>
<td>0.5 a</td>
<td>0.6 a</td>
</tr>
<tr>
<td></td>
<td>Chlordane</td>
<td>1.0 a</td>
<td>0.1 a</td>
<td>0.1 a</td>
<td>0.2 b</td>
<td>0.5 a</td>
<td>0.3 a</td>
</tr>
<tr>
<td>Sweet sorghum</td>
<td>No chlordane</td>
<td>5.5 a</td>
<td>1.1 a</td>
<td>1.0 a</td>
<td>1.6 a</td>
<td>0.7 a</td>
<td>0.6 a</td>
</tr>
<tr>
<td></td>
<td>Chlordane</td>
<td>2.8 b</td>
<td>0.7 b</td>
<td>0.0 a</td>
<td>0.0 b</td>
<td>0.1 b</td>
<td>0.4 a</td>
</tr>
</tbody>
</table>

Means in columns within crops followed by the same letter are not significantly different (\(P > 0.05\) using the \(F\) statistic; NS = \(P > 0.05\), * = \(P < 0.05\), and ** = \(P < 0.01\).)

\(^a\)Sampling periods: sweet sorghum 17 July - 23 September; sugarcane 17 July - 2 October.
APPENDIX B

Small plot insecticidal screening study
in sweet sorghum
A field of sweet sorghum, *Sorghum bicolor* (L.) Moench., located on the St. Gabriel Experiment Station, near Baton Rouge, La., was divided into plots each containing 3 rows spaced 0.91 m apart by 13.6 m long (0.004 ha). Insecticide treatments for season-long control of *D. saccharalis* were assigned to plots according to a randomized complete block design of 4 replications. Each spray concentration was applied to the sorghum plant canopy in water with approximately 289.2 liters (76.6 gallons) per ha of finished spray mixture at 137.9 kPa (20 psi) with a knapsack sprayer. Insecticide applications were begun after internodes were visible above ground and when at least 5% of the stalks contained small *D. saccharalis* larvae in leaf sheaths of Azodrin treated plots. Two applications were made (Aug 25, Sept 15). No soil applied insecticides were used. At harvest (Oct 7) two 15 stalk bundles were randomly taken from the center row of each plot. The stalks were examined for *D. saccharalis* entrance and exit holes. Insecticide efficacy was determined by comparing the percent internodes bored in treated plots with those taken from the untreated checks.

More than 60% suppression of season-long damage by *D. saccharalis* larvae was obtained with all insecticide treatments except Lorsban 4E applied at 1.12 kg [AI] ha (see Table 1). Azodrin 5L at 0.84 kg [AI] per ha was the most effective compound (82.8%) when compared to other tested compounds at indicated rates.
Table 1. Sugarcane borer control in sweet sorghum using insecticidal treatments compared with check plots at St. Gabriel, La., 1986.

<table>
<thead>
<tr>
<th>Treatment and kg [Al]/ha</th>
<th>Percent internodes bored</th>
<th>Percent control*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Azodrin 5L 0.84 ..........</td>
<td>2.6 a**</td>
<td>82.8</td>
</tr>
<tr>
<td>Alsystin 4E 0.56 ..........</td>
<td>3.5 ab</td>
<td>76.8</td>
</tr>
<tr>
<td>Baythroid 2E 0.028 ........</td>
<td>4.8 ab</td>
<td>68.2</td>
</tr>
<tr>
<td>Pydrin 2.4E 0.168 ..........</td>
<td>5.0 ab</td>
<td>66.9</td>
</tr>
<tr>
<td>Guthion 2EC 0.84 ...........</td>
<td>5.7 ab</td>
<td>62.3</td>
</tr>
<tr>
<td>Asana 1.9EC 0.034 ..........</td>
<td>5.9 ab</td>
<td>60.9</td>
</tr>
<tr>
<td>Lorsban 4E 1.12 ............</td>
<td>8.0 b</td>
<td>47.0</td>
</tr>
<tr>
<td>Untreated check ............</td>
<td>15.1 c</td>
<td>----</td>
</tr>
</tbody>
</table>

*Based on percent internodes bored in treated versus untreated (check).

**Means followed by the same letter are not significantly different at P < 0.05 according to Duncans' (1955) multiple range test.
APPENDIX C

Copyright Permission
Ms. Kate Kelly, Managing Editor
Entomological Society of America
4603 Calvert Road
College Park, MD  20740

Dear Ms. Kelly:

I am currently finalizing my dissertation for a Ph.D. degree in the Department of Entomology at Louisiana State University. The LSU Graduate school requires that all dissertations be microfilmed by University Microfilms Inc. The chapters of my dissertation are modified from four publications which will be either submitted or in various stages of publication in the Journal of Economic Entomology and Insecticides and Acaricides Tests (see attachment). Permission from the Entomological Society of America is requested for including these in my dissertation.

I would appreciate your approving correspondence regarding this matter.

Sincerely,

Billy W. Fuller
Graduate Student and Research Associate
ATTACHMENT


November 2, 1987

Billy W. Fuller  
Department of Entomology  
402 Life Sciences Building  
Louisiana State University  
Agricultural Experiment Station  
Baton Rouge, La. 70803

Dear Mr. Fuller,

The Entomological Society of America hereby grants permission for your use of the materials listed on the attached sheet in the preparation of your doctoral dissertation.

Sincerely,

Kate Kelly  
Managing Editor

encl.
VITA

Billy Wayne Fuller was born on August 1, 1953, in Jellico, Tennessee. He later moved to Phenix City, Alabama, where he attended Smith's Station High School from the first through twelfth grades. In 1972, he moved to the small town of Wadley, Alabama, to enter Southern Union State Junior College. After an Associate in Art with a major in Biology, he began four years of study at Auburn University where he earned a B. S. and M. Ed. with majors in biology and zoology, respectively. In 1978, he pursued an M. S. degree in Entomology at Clemson University where he worked with predator-prey relationships of the red imported fire ant in soybean. Upon graduating in August of 1982, he was employed by the USDA Cotton Insect Research Facility in Florence, South Carolina, where he did research on boll weevil migration and spider predation in cotton for two years prior to moving to Baton Rouge, Louisiana. At Louisiana State University he worked in the sugarcane insect pest management laboratory studying the bionomics of the sugarcane borer on sweet sorghum and completing a weed science minor.
Candidate: Billy Wayne Fuller

Major Field: Entomology

Title of Dissertation: Binomics of the sugarcane borer, Diatraea saccharalis in sweet sorghum Sorghum bicolor (L.) Moench.

Approved:

[Signatures]

Major Professor and Chairman
Dean of the Graduate School

EXAMINING COMMITTEE:

[Signatures]

Date of Examination:

November 19, 1987