Laboratory Evaluation of Feeding Preferences of Formosan Subterranean Termites, *Coptotermes formosanus* (Isoptera: Rhinotermitidae), on Cultivars of Pecan, *Carya illinoinensis*, in Texas

by

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**ABSTRACT**

The feeding preferences of *Coptotermes formosanus* Shiraki were evaluated on the wood of 56 field-collected pecan *Carya illinoinensis* (Wangenh) cultivars. It was evident from this study that Formosan termites had specific feeding preferences among the pecan cultivars evaluated. The 'Moneymaker' cultivar of *C. illinoinensis* was most preferred by *C. formosanus*, and the degree of feeding on this cultivar was significantly different ($P < 0.05$) from all other cultivars tested. 'Creek' was the least preferred cultivar, but the degree of feeding was not significantly different from other cultivars, with the exception of 'Moneymaker'. There was a trend for lower consumption of wood from commercially important versus native cultivars. This suggests that Formosan termites may be differentially attracted to a variety of pecan cultivars and/or chemicals associated with that wood. These results further demonstrate that pecan cultivars are at risk to *C. formosanus* feeding, and that future pecan cultivar selections should take into account this vulnerability.

Key Words: Formosan termites, *Coptotermes*, Pecan, *Carya*

**INTRODUCTION**

The economic impact of *Coptotermes formosanus* damage exceeds $1 billion annually as a result of feeding on houses, other buildings, utility poles, railway structures, boats, paper, and living trees (Edwards & Mill 1986; Su & Tamashiro 1987; Su & Scheffrahn 1990). In Texas, a *Coptotermes* species was first discovered in 1956 at the Houston Ship Channel in Pasadena (Harris Co.). The first established *C. formosanus* population in Texas was confirmed...
in Beaumont (Orange Co.), in 1962. By 1967, these termites were found in three states in the continental United States, and are presently established in 15 states, including Hawaii. This species is more destructive than native subterranean termites (Reticulitermes spp.) because of the larger colonies and foraging territories (Su & Tamashiro 1987; Su & Scheffrahn 1990; Gold et al. 1996). In addition, one of the unique characteristics of C. formosanus is its propensity to attack living trees. Unlike native termites, C. formosanus attacks at least 50 known plant species in the United States. Infestations in living trees often go undetected because of the cryptic and concealed nature of the feeding termites (La Fage 1987).

Infestations of C. formosanus weaken trees, often causing them to fall. These close associations with infested trees also threaten urban structures (Osbrink et al. 1999). The vast economic and ecological impact of C. formosanus has been most evident in the aftermath of hurricanes in the coastal areas of the United States during the past two decades. That is, high winds produced by these storms caused trees to fall due to structural weakening by feeding C. formosanus. After hurricane Andrew in 1992, 60% of 360 trees examined in New Orleans were found to be infested with C. formosanus. Investigations of coastal trees felled by Hurricane Rita determined that 40% of large trees marked for deposition in landfills were infested with these termites (Mcquaid 2009).

Controlling termites in infested trees is usually accomplished through exposure to slow acting, non-repellent insecticides either as liquids, foams or baits. Termite baits delivered via ingestion depend upon the consumption of the bait by the termites (Grace et al. 1996). Because of the aggressive foraging and feeding on cellulose by C. formosanus, termite baits could provide effective management. However, control of termites in pecan trees has several additional factors that confound control efforts. First, there are no insecticides labeled to treat the interior of nut or fruit bearing trees. Second, available treatments such as slow-acting baits may take months, years or may never achieve control (Glenn and Gold, 2003). Third, the termite bait matrix may not induce termites to feed when in the presence of optimal alternative food sources. Termites tend to ignore baits when an optimal food source, like pecan, is present (Morales-Ramos and Rojas, 2001). Fourth, the bark patterns on most pecan trees make detection via visual identification of termite infestations very difficult. Therefore, a rapid inspection for the presence of mud tubes on the outside of a tree, mud filled burrows near the base of a tree. Other methods of detecting these termites are not readily available. Tests by Morales-Ramos and Rojas showed that Formosan termites based on the use of in-ground wood blocks most impacted by Formosan termite colonies (Morales-Ramos and Rojas, 2001).

The objective of our research was to determine if infestations of C. formosanus could be picked up and isolated to evaluate whether cultivars were affected by C. formosanus attacks. Data collection would demonstrate feeding preferences of C. formosanus to evaluate whether cultivars were a key factor in the ability of this termite to attack pecan trees.

MATERIALS AND METHODS

Colony collection and culturing

Coptotermes formosanus colonies were collected in Beaumont, Texas (94.97W, 64°W) and La Grange, TX (30.04°N, 94.06°W) in 2002. The colonies were transported to the lab and kept in individually labeled plastic bags at room temperature until the use of in-ground wood blocks made for C. formosanus colonies in Beaumont, Texas (94.97W, 64°W) and La Grange, TX (30.04°N, 94.06°W). Three wood blocks, 2.54 x 15.24 x 0.64 cm (1 x 6 x 0.25 in), of the same species, were used to construct the block. Each block was drilled in the center of each block. A hole was dug in the soil to accommodate the wooden blocks placed in the center of each block. The assembled blocks were then placed on top, and covered with soil. The blocks were stored in individual 3.8 m³ buckets and baits were stored at room temperature until 3 d, the termites were tapped out of the bucket.
these termites were found in trees, and are presently established is more destructive than native because of the larger colonies and; Su & Scheffrahn 1990; Gold et characteristics of C. formosanus is the native termites, C. formosanus the United States. Infestations in the cryptic and concealed nature of these termites, C. formosanus the United States. Infestations in the cryptic and concealed nature of these termites, C. formosanus often causing them to fall. These threaten urban structures (Osbrink et al. 1996). Because of the aggressive, Formosan termites control of termites in pecan trees and control efforts. First, there are of nut or fruit bearing trees. Second, baits may take months, years (Gold, 2003). Third, the termite when in the presence of optimal food baits when an optimal food (Swain et al. 2003). Fourth, the taxonomic identification of termite infestations very difficult. That is, pecan bark morphology prevents rapid inspection for the presence of C. formosanus mud tubes formed on the outside of a tree, mud filled pruning scars, or the presence of termites at the base of a tree. Other methods of identifying termite infestations include audio/acoustic and movement sensory devices, but these are expensive and not readily available. Tests by Morales-Ramos and Rojas (2001) identified several preferred wood species, and pecan was clearly shown to be highly favored by Formosan termites based on the growth and survival of incipient colonies.

The objective of our research was to determine whether C. formosanus would demonstrate feeding preferences on wood of different pecan cultivars. Determination of C. formosanus consumption rates among cultivars was used to evaluate whether cultivars were at high or low risk to termite feeding.

MATERIALS AND METHODS

Colony collection and culturing
Coptotermes formosanus colonies were collected from three different locations. Two collection sites were located in Baytown, TX (29.73°32, 80°N, 94.97°70, 64°W) and (29.73°59, 98°N, 94.99°69, 45°W), and one in Beaumont, TX (30.04°07, 15°N, 94.06°85, 46°W). Colonies were collected with the use of in-ground wood blocks made of southern yellow pine (Pinus taeda L.). Three wood blocks, 2.54 x 15.2 x 15.2 cm, were connected by running all-thread rod (9 cm in length and 0.6 cm in diameter) through a 0.6 cm hole drilled in the center of each block. The blocks were then held in place by using wing nuts to attach both ends of the all-thread rod to form the feeding substrate. The assembled blocks were housed in a 3.8 m³ plastic bucket, with the bottom removed to allow the block to have direct contact with the soil. A hole was dug in the soil to accommodate the size of the bucket, and then the wooden blocks were placed in the center. The lid of the bucket was then placed on top, and covered with soil. This trap was left in the ground for a period of 1 month before being checked for the presence of C. formosanus. After termites were found in the traps, the blocks were removed and placed in individual 3.8 m³ buckets and brought back to the laboratory where they were stored at room temperature until sorting. After a period of no more than 3 days, the termites were tapped out of the blocks onto a plastic sorting tray. The
sorting device consisted of a 40.50 x 30.50 cm plastic tray tilted at a 20° angle which allowed the termites to move downward. At the bottom of the plastic tray, six 0.60 cm holes spaced 3.8 cm apart were connected to plastic tubing (0.60 cm in diameter and 7.60 cm in length). Through the tubes, termites dropped into a 33.00 x 19.10 x 11.40 cm acrylic plastic shoe box (Pioneer Plastics', USA Highway 41A North, Dixon Kentucky, 42409). Professional Choice' tongue depressors (15.2 cm) (Solon Company, Skowhegan, Maine, 04976) were soaked in water for 1 h to saturate them and leach out soluble chemicals. They were then placed on paper towels to dry for 5 minutes, and then cut into 3.80 cm pieces, and stacked in a 14.25 cm Petri dish (Nagle Nunc International, 75 Panorana Creek Drive, Rochester, New York, 14625). The 3.80 cm wood pieces were stacked in the Petri dish, one on top of the other, in a horizontal pattern. Two 7.60 cm pieces of tongue depressor were placed on top of the arrangement, to form a square. Two additional pieces were placed in the center as fillers. This pattern was continued until the depressors were stacked four rows high. These Petri dishes served as the standard culturing arenas. The termites were gently removed from the sorting system, and placed in the arenas, covered with lids, and stored in an environmental chamber at 29.4 ± 2°C and 85 ± 4% RH until initiation of the study.

Pecan wood collection and preparation
Cultivars were selected based on historical and commercial importance (Thompson and Young, 1985). Pruning shears were used to cut branches (cross-sections contained bark and heartwood) measuring 22.31 ± 3.48 cm in length and 2.52 ± 0.34 cm in dia, from 56 pecan cultivars (Carya illinoinensis), grown at the USDA Pecan Breeding and Genetics Program in Somerville, TX (30.31' 20.61'' N, 96.25', 24.64'' W). The wood samples were then placed in labeled Zip Loc® bags and brought back to the laboratory where they were stored at room temperature (25 ± 2°C and 55 ± 4% RH). These samples were then cut on a band saw using a fence to ensure that all were approximately 0.42 cm thick. These samples were then dried in a Fisher Scientific Isotemp oven (Fisher Scientific 2000 Park Lane Drive Pittsburgh, PA 15725) at 51°C for 8 hrs. After drying, they were allowed to cool to room temperature (25° ± 2°C), weighed to the nearest 0.1 mg, labeled and stored in labeled plastic bags until initiation of the experiments. These steps were taken in order to record a pre-feeding dry-weight for each wood wafer. At the initiation of the experiments, the wood wafers were placed in a 100 ml glass beaker containing moist sand. The wafers were allowed to soak for 5 minutes, after which they were placed in Petri dishes. Each Petri dish contained 250 termites that would provide moisture to preserve the wood.

Introduction of termites
Termites were removed from the sorting system for 30 minutes prior to testing to allow them to acclimate. One termitary was hand counted (250 termites) and placed in Petri dishes containing hay. The number of soldiers made up 5 to 15% of a termite colony. The number of soldiers present in the colony (250 termites) was divided to allow for more uniform handling. A single Petri dish with a single wood wafer was also placed in the Petri dish arena, a lid was placed on the Petri dishes to keep the wood wafers moist. Unlabeled and untreated wood pieces were also placed in the Petri dishes to control for plant material. Each Petri dish contained 250 termites, utilize wood wafers, a wood wafer with no termites, and a wood wafer with termites. These were placed in proximity to the termite arena. The percentage of termites remaining in each Petri dish was recorded at 5 minute intervals through time to estimate normal termite feeding behavior. The amount of wood consumed by the termites was then calculated from the weight gain or loss in the treatment Petri dishes. The percentage of dry-weight gain or loss was calculated from the weight of the wood wafers. Each Petri dish containing 250 termites, utilizing a wood wafer, and a wood wafer with no termites, was replicated three times. The study was conducted at 25 ± 2°C and 55 ± 4% RH and ran for 8 hrs. After 8 hrs, the Petri dishes were removed, cleaned, dried and weighed to the nearest 0.1 mg. The mean dry-weight was then used to calculate the amount of wood consumed by the termites.

Statistical data analysis
These experiments were designed as a completely randomized design and were replicated three times. The data were analyzed using General Linear Models, and Tukey’s Honestly Significant Difference (HSD) test was used to compare means (P < 0.05) (SPSS v. 16.0.1).
plastic tray tilted at a 20° angle. At the bottom of the plastic were connected to plastic tubing (th). Through the tubes, termites with acrylic plastic shoe box (Pioneer 1 Kentucky, 42409). Professional Company, Skowhegan, Maine, urate them and leach out soluble towels to dry for 5 minutes, and a 14.25 cm Petri dish (Nagle Nunc Rochester, New York, 14625). The one dish, one on top of the other, in tongue depressor were placed on additional pieces were placed continued until the depressors were served as the standard culturing in an environmental chamber at m of the study.

Introduction of termites
Termites were removed from the environmental chamber 1 wk prior to testing to allow them to acclimate to laboratory conditions. A total of 250 termites were hand counted (25 of which were C. formosanus soldiers) and placed in Petri dishes containing hydrated sand. In nature, Formosan termite soldiers make up 5 to 15% of a termite colony, therefore 25 soldiers were used in this study since foraging behavior is dependent upon the numbers of soldiers present in the colony (Mao, et al. 2005). Termites were placed in a single Petri dish with a single wood wafer. After C. formosanus were added to the Petri dish arenas, a lid was placed on top to retain the termites, and to keep the wood wafers moist. Untreated controls consisted of an arena containing a wood wafer with no termites, but prepared as described above with moist sand. This non-treated control was used to provide data regarding wood weight gain or loss in the treatment arenas. Additional untreated controls, each containing 250 termites, utilizing the standard culturing arena design, were placed in proximity to the testing array. These controls were monitored through time to estimate normal termite mortality. This experiment was replicated three times. The study was conducted in a darkened laboratory at 25 ± 2° C and 55 ± 4% RH and ran for 8 d. After 8 d had elapsed the wood wafers were removed, cleaned, dried and reweighed to determine the post-feeding dry-weight. This weight was then compared to the pre-weight to determine the amount of wood consumed by the termites.

Statistical data analysis
These experiments were designed to test the null hypothesis that C. formosanus would not show a significant preference for the wood of different pecan cultivars. General Linear Model (GLM) was used to analyze the data and Tukey’s Honestly Significant Difference (HSD) was used to separate means (P < 0.05) (SPSS v. 16.0.1).
RESULTS

Consumption of wood wafers by C. formosanus differed significantly (F = 15.49; df = 59,240; P < 0.05) based on GLM analysis of the 56 cultivars tested. The range of wood mass consumed by the termites was 0.017 to 0.637 g for the 'Creek' and 'Moneymaker' cultivars, respectively (Table 1). 'Creek' was the least preferred cultivar, while 'Moneymaker' was the most fed upon throughout 8 d. Coptotermes formosanus fed on 'Moneymaker' at a significantly greater (P < 0.05) level than all other cultivars. When ranked, the commercially important cultivars occurred along, and were dispersed throughout, the continuum of cultivar preferences shown in Table 1 and Fig. 1. However, it is important to note that five of the six cultivars most preferred by C. formosanus were considered commercially important in present day pecan production (Table 1). Termites in the untreated controls for this experiment suffered less than 10% mortality throughout the 8 d period. The mean weight difference for the untreated controls of all 56 cultivars was 0.003 g. The mean consumption values of all 56 cultivars through three replications over an 8 d period are presented in Table 1.

DISCUSSION

It was determined that C. formosanus foragers differentially preferred to feed on the wood of specific pecan cultivars. Of the 56 cultivars examined, 'Creek' and 'Barton', had only 2.71% as much cellulose removed by termite feeding as did the commercially important cultivar 'Moneymaker'. The concept of acquired or selected traits through plant breeding programs that are performed by the scientists at the USDA Pecan Breeding and Genetic Program, Southern Plains Agricultural Research Center, would pertain to those cultivars with resistance or tolerance to termite feeding. It is apparent that they have successfully bred for traits such as yield, disease resistance, and tolerance to many insect groups. However, to this point in time, little or no attention has been given to termite feeding in the selection processes. Based on the results of this research, there are traits that could result in diminished termite feeding.

It is highly probable that breeding for traits that are resistant to termite feeding could be incorporated into the commercial cultivars through time. More work would need to be done to identify the specific characteristics...
Table 1. Summary of the mean consumption of wood from 56 pecan cultivars by 250 Formosan termites in laboratory studies conducted over an 8 d period.

<table>
<thead>
<tr>
<th>Rank</th>
<th>Cultivar</th>
<th>Mean Consumption (g)</th>
<th>Rank</th>
<th>Cultivar</th>
<th>Mean Consumption (g)</th>
<th>Rank</th>
<th>Cultivar</th>
<th>Mean Consumption (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Creek</td>
<td>0.017±0.004</td>
<td>20</td>
<td>Warren</td>
<td>0.067±0.020</td>
<td>39</td>
<td>Riverside</td>
<td>0.123±0.023</td>
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<tr>
<td>2</td>
<td>Clark</td>
<td>0.019±0.009</td>
<td>21</td>
<td>Shawnee</td>
<td>0.069±0.024</td>
<td>40</td>
<td>Schley</td>
<td>0.126±0.010</td>
</tr>
<tr>
<td>3</td>
<td>Wichita</td>
<td>0.028±0.011</td>
<td>22</td>
<td>Oconee</td>
<td>0.069±0.032</td>
<td>41</td>
<td>Desirable</td>
<td>0.134±0.032</td>
</tr>
<tr>
<td>4</td>
<td>Nacabo</td>
<td>0.029±0.007</td>
<td>23</td>
<td>Forkert</td>
<td>0.069±0.009</td>
<td>42</td>
<td>Baker</td>
<td>0.138±0.067</td>
</tr>
<tr>
<td>5</td>
<td>Hopi</td>
<td>0.029±0.015</td>
<td>24</td>
<td>Apache</td>
<td>0.070±0.010</td>
<td>43</td>
<td>Moore</td>
<td>0.141±0.031</td>
</tr>
<tr>
<td>6</td>
<td>Chickasaw</td>
<td>0.041±0.017</td>
<td>25</td>
<td>Burkett</td>
<td>0.071±0.024</td>
<td>44</td>
<td>James</td>
<td>0.147±0.029</td>
</tr>
<tr>
<td>7</td>
<td>Barton</td>
<td>0.045±0.020</td>
<td>26</td>
<td>Cadle</td>
<td>0.075±0.021</td>
<td>45</td>
<td>Woodside</td>
<td>0.166±0.026</td>
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<tr>
<td>8</td>
<td>Osage</td>
<td>0.045±0.013</td>
<td>27</td>
<td>Carter</td>
<td>0.075±0.004</td>
<td>46</td>
<td>Schaeffer</td>
<td>0.162±0.032</td>
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<tr>
<td>9</td>
<td>Kiowa</td>
<td>0.046±0.023</td>
<td>28</td>
<td>Mississippi</td>
<td>0.081±0.025</td>
<td>47</td>
<td>Philema</td>
<td>0.167±0.071</td>
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<tr>
<td>10</td>
<td>Apache #5</td>
<td>0.051±0.022</td>
<td>29</td>
<td>San Felipe</td>
<td>0.096±0.011</td>
<td>48</td>
<td>Alyce</td>
<td>0.180±0.041</td>
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<td>11</td>
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<td>0.054±0.027</td>
<td>30</td>
<td>Nelson</td>
<td>0.096±0.009</td>
<td>49</td>
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<td>Houna</td>
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<td>Ramsey M.</td>
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<td>Mahan</td>
<td>0.193±0.019</td>
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<td>14</td>
<td>Chocotate</td>
<td>0.058±0.008</td>
<td>33</td>
<td>Cherryle</td>
<td>0.107±0.006</td>
<td>52</td>
<td>Giles</td>
<td>0.218±0.077</td>
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<tr>
<td>15</td>
<td>Candy</td>
<td>0.059±0.032</td>
<td>34</td>
<td>Mohawk</td>
<td>0.109±0.018</td>
<td>53</td>
<td>Brake</td>
<td>0.302±0.208</td>
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<tr>
<td>16</td>
<td>Kanza</td>
<td>0.059±0.008</td>
<td>35</td>
<td>Van Dornan</td>
<td>0.112±0.020</td>
<td>54</td>
<td>Cooper</td>
<td>0.358±0.257</td>
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<tr>
<td>17</td>
<td>Woodroof</td>
<td>0.061±0.008</td>
<td>36</td>
<td>Sioux</td>
<td>0.117±0.051</td>
<td>55</td>
<td>Smart</td>
<td>0.361±0.066</td>
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<tr>
<td>18</td>
<td>Shoshoni</td>
<td>0.062±0.025</td>
<td>37</td>
<td>Hughes</td>
<td>0.118±0.019</td>
<td>56</td>
<td>Moneymaker</td>
<td>0.637±0.080</td>
</tr>
<tr>
<td>19</td>
<td>Comanche</td>
<td>0.066±0.018</td>
<td>38</td>
<td>Waukeenah</td>
<td>0.121±0.019</td>
<td>57</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Indicates a commercially important cultivar based on the number of trees currently in production (Texas in 2009).

Means followed by the same letter were not significantly different using ANOVA, and Tukey HSD (Honestly Significant Difference) (SPSS v.16.0).
that would have commercial value, survivability of selected cultivars. Undergo the selection process, the replacement stock. It is inevitable move into pecan production areas and eventually killed.

In addition to loss of trees by Formosan areas, pecans are a popular ornament of aesthetics and nut production. If trees are attacked by Formosan termites, the risk of these trees falling on structures in high wind situations. (Edwards & Scheffrahn 1990). Therefore, if a high tree in urban landscapes, some degree of infestation can be added to the decision of specific pecan cultivars.

This research reveals the potential on the pecan agro-industry. For this reason, it may offer some additional information which should enhance the need for research. However, research is needed before infestation can be added to the decision of specific pecan cultivars.

ACKNOWLEDGMENTS

We thank the several people who specifically Drs. Tommy Thompson of the Pecan Breeding and Genetics Program to the pecan cultivars evaluated experimental design, and helped in the USDA-ARS National Formosan project. helped in the funding of this study.

Fig. 1. Mean consumption of wood from 56 pecan cultivars by 250 Formosan termites in laboratory studies conducted over an 8 d period.
that would have commercial value in attempting to balance nut yields to survivability of selected cultivars. Because it takes considerable time to undergo the selection process, the results of this research would indicate that there are cultivars presently available that could be moved to production as replacement stock. It is inevitable that Formosan termites will continue to move into pecan production areas, where the trees will be found, fed upon and eventually killed.

In addition to loss of trees by Formosan termites feeding in commercial areas, pecans are a popular ornamental tree used in urban landscapes because of aesthetics and nut production. In these urban situations, when the pecan trees are attacked by Formosan termites, the aesthetic value is reduced and the risk of these trees falling on structures is increased, particularly during high wind situations. (Edwards & Mill 1986; Su & Tamashiro 1987; Su & Scheffrahn 1990). Therefore, if a less preferred pecan cultivar is used, even in urban landscapes, some degree of risk can be mitigated.

This research reveals the potential impact Formosan termites will have on the pecan agro-industry. For the commercial pecan grower, these results may offer some additional information regarding specific cultivars at risk, which should enhance the need for regular inspections for invading termites. However, research is needed before inclusion of the risk of C. formosanus infestation can be added to the ‘decision rubric’ with regards to the production of specific pecan cultivars.

ACKNOWLEDGMENTS

We thank the several people who assisted in the conduct of this research, specifically Drs. Tommy Thompson and Larry J. Grauke of the USDA-ARS Pecan Breeding and Genetics Program, Somerville, TX. They provided access to the pecan cultivars evaluated in this work, provided inputs into the experimental design, and helped in securing funding through the USDA-ARS Agreement No. 58-6202-8-136. We also appreciate the support from the USDA-ARS National Formosan Subterranean Termite Program, which helped in the funding of this study.
REFERENCES


Movement of Chlorantraniliprole in Sandy Loam and Silty Clay Subterranean Termites

Neil A. Spomer1, Shripat T. Kamble2

ABS

The movement of chlorantraniliprole in sandy loam and silty clay loam soil movement occurred in sandy loam (SCL) soil with 90.27% of applied 5 cm of SCL columns. Indoxacarb movement differences in both SL concentrations (0 to 1.2 mg L⁻¹) were above solubility limit. Effluent indoxacarb was initially well above the solubility limit remained near the point of application through soil columns.

Key Words: Chlorantraniliprole, Subterranean termites

INTRO

Subterranean termites cause 80% of the economic damage and are considered one of the most damaging pests in the world. Chlorantraniliprole and indoxacarb ingredients (AI) with novel modes of action.

Chlorantraniliprole (3-methylcarbamoylphenyl)-1-(3-carboxamide) is a novel chemistry insecticide with a mode of action to prevent the synthesis of juvenile hormone, which is essential for termite development. The/silica particles

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4DuPont Professional Products, Wilmington, DE 19880

Acronyms:

AI: Active ingredient
- 200 Sociobiology Vol. 57, No. 1, 2011

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Acronyms:

AI: Active ingredient
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