Hexanes as Deterrents in Tribolium

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Abstract

Red flour beetles are a serious pest to stored grain crops (United States 2015). Many different studies have been and are currently being done to find new anti-feedant deterrents to keep these beetles from infesting or destroying grain stores. I opted to study hexane compounds because hexane extracts significantly indicate anti-feedant activity (Rajopadhye et al. 2016). Ethanol extracts have also shown to be useful anti-feedant deterrents (Khan et al 2016).

Through my study, I found that a significant number of red flour beetles avoided most of the hexane compounds tested. While it is currently unknown how these compounds would react as long-term deterrents, it has been shown that some of the tested compounds do have the potential to be at least a short term deterrent.

Purpose

The purpose of this research is to test repellent properties in hexane solutions for red flour beetles.

Questions, Hypotheses, and Predictions

Question: What kind of compounds could be used to protect grain stores from red flower beetles?

Hypothesis: Compounds dissolved into hexane solutions are a deterrent to red flower beetles.

Prediction: Beetles will avoid areas treated with hexane solutions.

Study System

The red flour beetle (*Tribolium castaneum*) is a pest beetle which attacks stored grain products. It is a model organism and is used in many labs for research. It is originally of Indo-Australian distribution, but has become a worldwide pest and is considered to be one of the most common pests in stored grains throughout the world.

The red flour beetle can live for up to three years and was once thought to be relatively sedentary, but they have recently been found to be able to greatly expand their range by flight. They are less likely to be able to survive outdoors than their cousin, the confused flour beetle (*Tribolium confusum*), which is why it is a considerable pest to stored grain products.

The red flour beetle and the confused flour beetle are very physically similar, but are best distinguished from each other by the number of clubs on the ends of each antennae. The red flour beetle has three clubs, while the confused flour beetle has four.

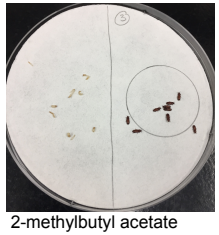
Methods and Experimental Design

For this experiment, a circle was drawn onto the right half of a piece of filter paper. Fifty microliters of water was applied to the left side and fifty microliters of the the test solution (at 10% concentration) was applied to the circle on the right and both liquids were completely dried. The filter paper was placed in a petri dish and ten beetles were added to the center of the dish. The dishes were then covered using foil and left. After one hour had passed, the dishes were uncovered and beetles on either half of the dish were counted. Beetles on the left side of the dish were considered to be avoiding the compound applied to the right side and beetles on the right were considered to be attracted to (or negatively avoided) the compound.

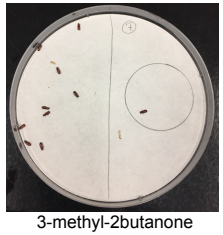
The compounds that were used in this project were: n-tridecane ($C_{13}H_{28}$), myrcene ($C_{10}H_{16}$), 2-methylbutyl acetate ($C_7H_{14}O$), 2-hexanol ($C_6H_{14}O$), carvacrol ($C_{10}H_{14}O$), 3-methyl-2-butanone ($C_5H_{10}O$), 1-nonanol ($C_9H_{20}O$), and heptadecane ($C_{17}H_{36}$). Chemical structure for these compounds vary from long, unbranched carbon chains to structures including a benzene ring, to the branched and double bonded chain of myrcene.

Results

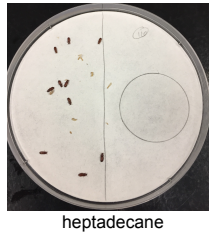
The results from these tests tended to show that with most of the compounds, the majority of the beetles either completely avoided or were completely attracted to the compound. Only one of the compounds, 2-methylbutyl acetate, showed an attraction factor for the beetles. In both tests, 100% of the beetles in the dish were located within or very near the circle. In other tests, the beetles tended to stay on the left side of the dish, appearing to be actively avoiding the compound on the other side.



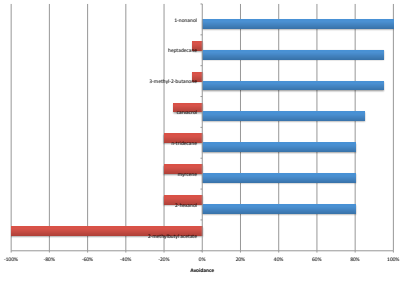
2-methylbutyl acetate



3-methyl-2butanone



heptadecane



The graph to the left shows the percentage of avoidance (attraction is negative) of the beetles to the compounds used. The three compounds tested which show 95-100% avoidance are statistically significant ($p<0.0114$) in supporting the hypothesis that there are compounds dissolved into hexane solutions which are deterrents to red flour beetles.

Conclusions

From this study, it was found that there are a number of compounds that act as repellents to red flour beetles for at least a short time. This is important for the grain industry because these results may be able to lead to the development of future compounds that will be able to deter the beetles from getting into grain stores while not causing harm to the stores themselves. Plant compounds such as myrcene have mixed results, but may be able to be combined with other compounds to create a more consistent result.

Future Directions

For future projects, I feel as though there are a great number of questions to ask from this research. For example, how do the beetles respond to longer exposure to the solutions. Would the beetles still avoid the same solutions at 1 day or even a week? Similarly, adjusting the concentration of the solutions to see how the beetles would react to both a higher and lower concentration. Would the behavior of the beetles be changed if they were starved and there was food inside of the circle that had the solution applied to it? If they are willing to cross over the solutions to get to the food, would they still be interested in eating it if it had also had the solution applied to it? Or does the food lose its appeal because of the added solution? If these eight solutions were mixed, how would it affect the deterrent factor? Does mixing two or more solutions increase or decrease deterrence?

With these questions in mind, future testing can be done to find a compound or mixture of compounds that could have long-term repellent effects for deterring the beetles from getting into storage areas or packaged containers or grains. Uses for these repellents could be applied to packaging of flours and grains and pet foods and keep the beetles out while not having any effect on the product being stored.

References

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