POTENTIAL INSECT DETERENCE IN TRI-SPECIES COTTON HYBRID

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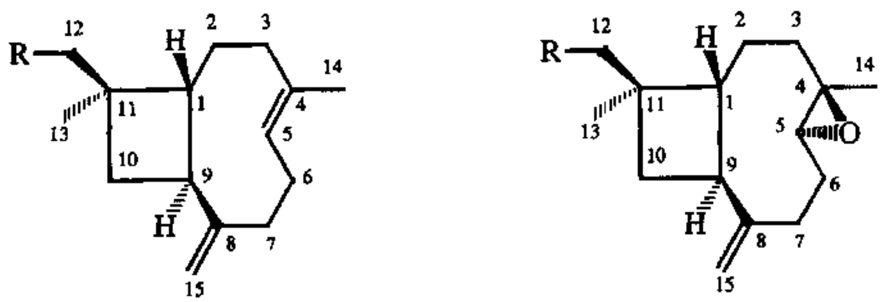
Abstract

In the Southern United States, the fall armyworm, *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae) is of economic importance, threatening several agronomic crops and acting as a primary pest of commercial cotton (*Gossypium hirsutum* L.). Plant incorporated Bt toxins have been the primarily means of managing fall armyworm in cotton. However, resistance to these toxins have led to renewed interests of host plant resistances as a more sustainable approach to fall armyworm management. Caryophyllene derivatives in tri-species cotton hybrid have demonstrated resistance to nematodes, root rot, and Fusarium wilt, but its impact on cotton insect pests is unknown. The objective of this study was to determine the survival and development of larvae feeding upon the leaves of tri-species cotton hybrids expressing caryophyllene derivatives. Our results demonstrate that tri-species cotton hybrids producing caryopyllene alcohol negatively affect fall armyworm development.

Introduction

William et al. (1997) identified natural insecticide, ^{2}-caryophyllene and its derivatives (Figure 1) as the most abundant volatile sesquiterepenes from essential oils in wild cotton. Caryophyllene and its derivatives: 1) 12-hydroxy-^{2}-caryophyllene; 2) 12-hydroxy-^{2}-caryophyllene acetate; 3) 12-hydroxy-^{2}-caryophyllene oxide acetate believed to reduce insect injury and populations previously detected in some wild cotton species. USDA-ARS scientists revealed two genes to account for the production of caryopyllene derivatives, later incorporating these genes into a tri-species hybrid: *G. armourianum, G. arboreum,* and *G. hirsutum* to increase resistance to unfavorable agronomic conditions.



1. R=HO
2. R=AcO
3. R=AcO

Figure 1. Chemical structure of ^{2}-caryophyllene and its derivatives. William et al., 1997

Spodoptera frugiperda (J.E. Smith) (Lepidoptera: Noctuidae), is an agronomic pest of several cultivated crops (Barros et al., 2010) and a primary pest of cotton (*Gossypium hirsutum* L.) in the southern United States. Infestations occur infrequently in cotton; as a result, effective pest management of the fall armyworm is difficult to achieve (Hardke et al., 2015). Destructive pest populations are treated with conventional insecticides and transgenic cottons, which contain *Bacillus thuringiensis* (Bt) protein toxins. However, Luttrell and Mink (1999) concluded, the fall armyworm is one of the least susceptible lepidopterans to the Bt Cry proteins expressed in cotton. Resistance to primary control strategies in cotton production has demanded additional integrated pest management (IPM) efforts such as host plant resistance (HPR).

Materials and Methods

Plant Source

The tri-species cotton hybrid (*G. armourianum, G. arboreum,* and *G. hirsutum*) developed at USDA Southern Plains Agricultural Research Center in College Station, Texas was used in this study. Plants were maintained in a greenhouse and separated into three treatments: caryophyllene (control), caryophyllene alcohol, and caryophyllene acetate and alcohol. Caryophyllene and its derivatives were identified with the gas chromatography mass spectrometry (GC-MS) and results were used to separate plants into different treatments.

Insect Source

A susceptible strain (SS) of *Spodoptera frugiperda* was collected from a non-Bt corn field in Franklin Parish, Louisiana. SS has been documented to be susceptible to Cry1F, Cry1A.105, Cry2Ab, Cry2Ae, and Vip3A Bt protein toxins (Chen et al., 2018).

No-Choice Bioassay

Larval survivorship and development of *S. frugiperda* was determined on leaf tissue of an upland germplasm (caryophyllene) and tri-species cotton hybrids, each expressing a different caryophyllene derivative (caryophyllene alcohol, and caryophyllene acetate and alcohol). Seven of each caryophyllene and caryophyllene alcohol and fourteen of caryophyllene acetate and alcohol producing hybrid plants were used in this study. A single fully expanded leaf, was excised from nodes X-Y, 4 from each plant. These leaves were pooled and then distributed into 4 unequal replicates; replicates 1 and 3 contained 4 leaf sub-samples while replicates 2 and 4 contained 3 leaf sub-samples. Each leaf was placed adaxial side up into a sterile Petri dish (100x15 mm) lined with moistened filter paper. Five neonates (<24h old) were placed on the surface of each leaf. The dishes were sealed with a lid and placed in a growth chamber maintained at 27 ± C, ~50% RH, and a photoperiod of 14:10 (L: D). Filter paper was saturated daily and leaves replaced when needed. Each hybrid and insect was replicated four times and each replication had 70 larvae (n = 4 x 70 = 280). Larval mortality, weight, and instar development was recorded seven days after infestation.

Data analysis

Survivorship, larval instar, and development data was analyzed using PROC GLIMMIX (PROC GLIMMIX SAS Institute Inc. 2011). All data was analyzed using random effect of hybrid*rep. A one-way analysis of variance (ANOVA) with germplasm (caryophyllene (control), caryophyllene alcohol, and caryophyllene acetate and alcohol) set as the treatments. Means were separated using Tukey-Kramer Grouping of least square means (LSM) test at ± = 0.05.

Results and Discussion

The effect of caryophyllene and its derivatives on fall armyworm surviorship and larval instar was not significantly different (Figures 2 and 3). However, the average weight of the larvae feeding on caryophyllene alcohol was signifcantly lower than those feeding on caryophyllene and caryophyllene acetate and alcohol (Figure 4). This study indicates caryophyllene alcohol treatment negatively affected fall armyworms abiltiy to develop size although instar was not affected (Fig. 3). Further evaluation is required to fully assess the impact caryophyllene alcohol has on fall armyworm's abiltiy to develop and injure cotton. Additionally, the impact of these tri-species cotton hybrids producing caryophyllene derivatives have on other cotton pests should be evaluated.

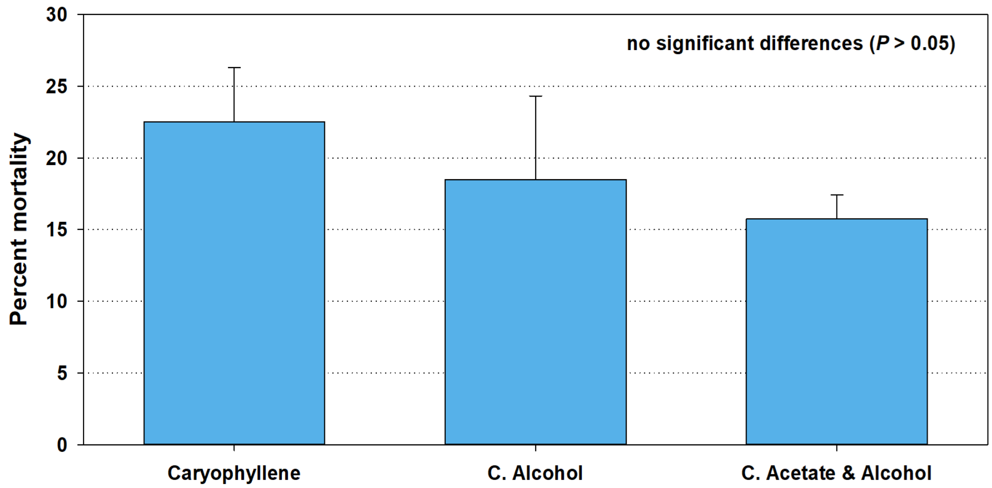


Figure 2. Survivorship of FAW feeding on tri-species cotton hybrid.

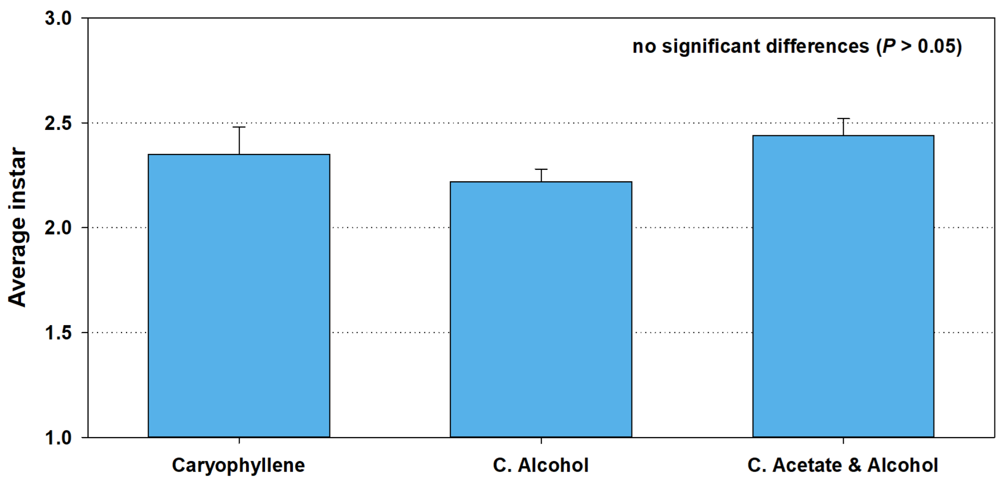


Figure 3. Average instar of FAW feeding on tri-species cotton hybrid.

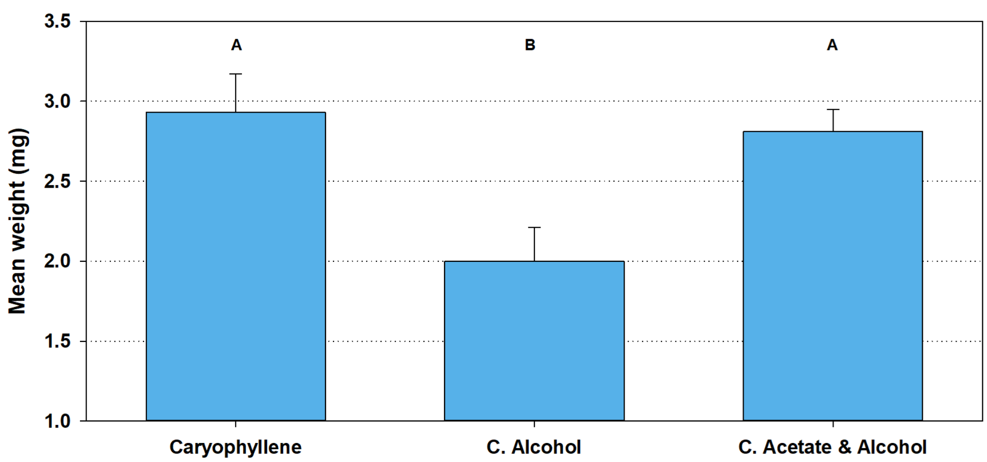


Figure 4. Development of FAW feeding on tri-species cotton hybrid.

References

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