EFFECT OF LEAF COLOR ON ARMYWORM DEVELOPMENT

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Abstract

In cotton, the beet armyworm, *Spodoptera exigua*, (Hübner) are sporadic but economically important pests. Traditional control measures rely on the use of costly insecticides. Little research has been done on possible host plant resistance mechanisms. In 1998, it was observed that cotton germplasm expressing the red leaf color phenotype showed less foliar damage than normal green leaf color genotypes. In 1999, studies were performed to assess the effect of leaf color on armyworm development. Fresh leaves of closely related green and red cotton genotypes were placed in petri dishes and infested with 72 hour old larvae of laboratory reared colonies. Larval weight gain was recorded at 2 day intervals for a period of 10 days. The possible utility of cotton leaf color as a host plant resistance mechanism which functions by antibiosis was shown by the no-choice feeding studies performed.

Introduction

Cotton, *Gossypium hirsutum* L., provides mankind with four basic raw materials: fiber, oil, animal feed and base chemicals for industry. As the world's population increases, the need for renewable resources will increase and the non-renewable resource base will decrease. Cotton, as a renewable resource, can help supply these future needs if its genetic potential can be realized. Furthermore, compared with many other fiber materials, cotton has a superior hand or feel and is biodegradable. The problem is that there are many limitations to the reaching of this genetic potential.

Insect pests are one of the major limitations of cotton production worldwide. Producers and plant breeders are always trying to find new and innovative methods to combat these pests, since agricultural insecticides are often expensive and under tight regulatory control. One such method is host plant resistance. This method can be cost efficient and long lasting compared to pesticides (Panda, 1979).

The beet armyworm, *Spodoptera exigua*(Hübner), is known for being a sporadic pest, but as other primary pests are eliminated, there is the potential for them to become a greater problem throughout the cotton belt. The beet armyworm feeds on foliage, but has been known to feed, in later instars, on the fruiting forms (eg. squares, flowers and bolls) of the cotton plant. Since the insecticides used to control these pests are costly, more cost effective control methods need to be investigated.

Red plant color is a trait often used in cotton host plant resistance studies. It varies from an intense, whole plant color(eg. R_1, R_1^{dar}, and R_d genotypes) to a marginal(R^m genotype) leaf color. These differences are easily identified on living plants. Red plant color, however, is associated with poor agronomic performance in cotton. According to Jones et. al. (1978), yield trials with near-isogenic lines of red leaf and green leaf cotton indicated significant and consistent yield reductions associated with red plant color.

Historically, host plant resistance in crop plants is a classical method of insect pest control. According to Bailey et. al. (1980), it is a method of reducing dependence on insecticides in cotton. Plant chemical composition has been studied by many researchers to see what chemicals serve as phagostimulants and deterrents (Loughrin et. al. 1995). However, little is known about the influence of plant color on the feeding behavior of the beet armyworm.

The objective of this study was to investigate whether or not red plant color could be a useful tool in combating the beet armyworm in cotton production. This was done using a no-choice feeding study as a measure of the difference in larval growth when fed red and green cotton leaves.

Material and Methods

Insects

Beet armyworms were obtained from colonies reared at the Department of Entomology at Louisiana State University on artificial diet. Sufficient numbers of insects were generated using the method of Adamczyk et. al. (1998).

Cotton Varieties

Cotton varieties used in this study were LaKate and TM-1. LaKate was developed from a cross made in 1987, by LA Agr Exp Station, between TX CDP 37-HH and LA Super Red Dwarf-861487. TX CDP 37-HH is a cultivar released by the Texas Agr. Exp. Station. The parents of LA Super Dwarf Red are LA 770659-Rsne and TM-1Rd (J. E. Jones, personal communication). According to Kohel et. al. (1970), TM-1 was selected at the Texas Agr Exp Station, in 1947, from the commercial variety 'Deltapine 14', which had been released by the Delta and Pine Land Company of Scott, MS in 1941. These two lines, LaKate and TM-1, were chosen because TM-1Rd, parent of LaKate, and TM-1 are related, and TM-1 is a standard reference cotton for genetic and cytogenetic experimentation (Kohel, 1970).

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Research Location
Cotton varieties used in this study were field grown at the Ben Hur Research Farm (Louisiana State University Agricultural Center, Louisiana Agricultural Experiment Station) near Baton Rouge, LA.

Survival and Development of Armyworms Fed Cotton Foliage
To compare survival and development on the red and green leaf color germplasm lines, leaves from both varieties were selected according to their location on the plant and their age, usually between the third and seventh node. Larvae were reared 72 hours on prepared diet(fig. 1) then placed on individual leaves inside 9.2-cm-diameter plastic petri dishes with a 9.0-cm-diameter filter paper disc (moistened as needed to prevent leaf dessication) and covered to prevent escapes. Twenty-five separate petri dishes were prepared for each leaf color. Leaves were changed every 48 hours when larvae weights were recorded. Twenty-five control plates of prepared diet were also included in the study to show a normal growth rate. The study was conducted in a growth room maintained at 27º ±2ºC and with a photoperiod of 14:10 (L:D) h for a ten day sampling period. This basic design was replicated until 4 replications had been completed. Within each replication, petri dishes were completely randomized. Data collected on larval weight gain were analyzed using regression analysis.

Results

Larval weights were averaged across replications to show general growth patterns of the beet armyworm on the three treatments(prepared diet, green foliage and red foliage). Figure 2 shows that those larvae which were fed the prepared diet far surpassed the two foliage treatments. It also shows that those larvae which were fed the green foliage outweighed those that were fed the red foliage. Linear regression slopes for both the foliage treatments were calculated (fig. 3). Table 1 shows that for the green foliage treatment the slope of the line was 2.765± 0.2847, with a $R^2 = 0.81$ and the Y-intercept to be -1.588 ± 1.724. The table also shows that for the red foliage treatment the slope of the line was 1.841 ± 0.159, with a $R^2 = 0.859$ and the Y-intercept to be -0.4484 ± 0.9626. A comparison to see if the two slopes were equal yielded a F value = 8.03645 and a p value = 0.006899 which showed that the two slopes differed significantly.

Discussion

According to Schoonhoven et al (1998),attempting to increase agricultural production in order to supply a world population which is increasing at an approximate rate of 1.6% per year, to reduce the use of synthetic pesticides and to change current agriculture systems into more sustainable systems information gained from insect-plant interactions may be helpful if not invaluable. Since the beet armyworm is highly resilient and adaptable, problems with this pest in cotton will continue to increase (Ruberson, 1996). Data acquired in this study reveals that the beet armyworm has a higher weight gain when fed green foliage as compared to red foliage across time. This allows previously accrued information from other insect-plant interactions to be useful in determining the type of host plant resistance found here.

Antibiosis is the classification of resistance that includes detrimental effects on insect life history which result after a resistant host plant is used for food (Painter, 1951). According to Smith et al (1994), identification of antibiosis can be done by no choice feeding studies using plant materials. Antibiosis can be measured by larval survival, metabolic utilization of ingested food, larval development, weight increase, adult longevity , fecundity, egg hatchability, and population increases (Smith et al, 1994).

Since larval weight gain was chosen to be measured, and the slopes comparing larval weight gain from the red foliage treatments compared to the green foliage treatments were determined to be significantly different, one can assume that there are antibiotic properties associated with the red plants used in this study. The differences between the larvae fed the prepared diet and those that were fed foliage were expected, since the diet includes proteins and sugars that optimize larval growth. These antibiotic properties of the red foliage cotton maybe useful to the many plant breeders working to find new ways to make their varieties perform under sustainable agricultural systems. However, the yield reductions associated with incorporating red plant color will need to be resolved before this trait can be successfully used or an acceptable compromise will need to be reached.

Although red foliage retarded the growth of the beet armyworm, it is suggested that red foliage not be used as a stand alone control for the beet armyworm because of the lack of information on this and other insect-plant color interactions in cotton. However, once more studies are done, using plant color interactions it is suggested that red plant color can aid in overcoming rapid population increases of the beet armyworm.

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Table 1. Linear Regression of Foliage Treatments

	Green	**Red**
Slope±S.E.	2.765±0.2847	1.841± 0.159
Y-Intercept±S.E.	-1.588±1.724	-0.4484±0.9626
R^2	0.8109	0.8591

Table 2. Comparison of Slopes

F = 8.03645	
DFn = 1	DFd = 44
P = 0.006899	

1650 ml	Water
78 g	Soybean Protein (grade II)
78 g	Sugar
66.5 g	Wheat Germ
45 g	Agar
19 g	Wesson Salt Mix
18 g	Vanderzandts Vitamin Mix
3.8 g	Methyl Paraben
3 ml	Diet Acid (209 ml Proprionic Acid + 21 ml Phosphoric Acid + 270 ml Water)
2 ml	Formalin (37% Formaldehyde)
1.9 g	Sorbic Acid
0.125 g	Chlortetracycline

Figure 1. Prepared Diet Ingredients

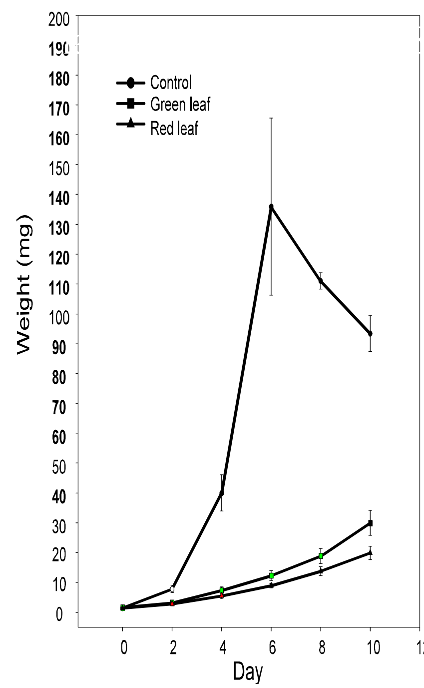

Figure 2. Average Weights Across Replications

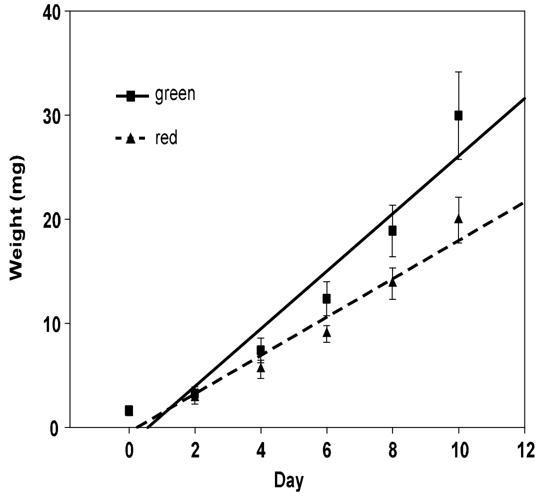

Figure 3. Linear Comparison of Green Foliage vs. Red Foliage