CHANGES IN THE BIOCHEMICAL COMPOSITION OF COTTON LEAVES AS RELATED TO COTTON APHID POPULATION DYNAMICS

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Abstract

Cotton aphids (Aphis gossypii, Glover) have become a major pest on the High Plains of Texas. The cotton producer is affected by increasing control cost as well as yield reductions. Another problem, lint contamination or "sticky cotton" is associated with aphid honeydew. Research was conducted to determine if the changes in the sugar and amino acid composition of cotton leaves during boll development were related to developing aphid numbers. Leaves developing under different water treatments and associated with fruit of various ages from flower to open bolls were analyzed for both chemical constituents and aphid densities. The results did not indicate a strong relationship between the biochemical composition and aphid densities on individual leaves.

Introduction

Cotton aphids have been considered a problem in cotton on the High Plains of Texas since 1975 (Leser, 1994). The ability to control aphids has become more difficult. Aphid numbers remain relatively low early in the growing season on the High Plains, but begin to increase in mid-to-late July and reach their peak by late August (Slosser, et al., 1998). Aphid numbers increase concurrent with the increasing boll load. This led to the hypothesis that the biochemical change in soluble sugar and amino acid concentrations in the leaf feeding different age bolls may influence the rapid changes in aphid numbers. Developing cotton bolls have the greatest demand for amino acids during the first 30 days after pollination. Beginning about 20 days after pollination there is an increasing demand for sugars resulting in cellulose and oil deposition. As cotton leaves export amino acids and sugars to meet the demand of the developing boll, the change in the relative composition of soluble organic compounds in the leaf provides the aphid with a food source high in amino acids that may increase its ability to reproduce at higher rates. The study was conducted to identify the changes in the biochemical composition of cotton leaves during boll development and relate these changes to aphid numbers. Leaves were evaluated under different water regimes to identify the role of water stress on amino acid and sugar concentrations.

Materials and Methods

The experiment was conducted at the Crop Production Research Lab in Terry County, Texas (approximately 35 miles southwest of Lubbock) during 1998 and 1999. Cotton was grown under a center pivot (LEPA) that was equipped to apply different volumes of water (2, 3, and 5 gallons per minute per acre) per revolution resulting in varying levels of plant water stress during the growing season. Leaves were collected at peak bloom, ten and approximately twenty-five days after peak bloom. Mainstem leaves were collected from the 7^{th}, 10^{th}, and 14^{th} node from plants within each water environment. Ten leaves were collected from each position at each sampling date. The number of cotton aphids was counted on each leaf, and an average was recorded for that environment. One disk (2 cm^2) was removed from each leaf to determine the specific leaf weight (g/cm^2). Then the ten leaf disks were ground in 80% ethanol using a Polytron tissue homogenizer. Norit A, decolorizing charcoal, was used to remove the chlorophyll from the extract. The soluble amino acid composition of the extract was determined using the Ninhydrin reaction and absorbance was measured at 570nm (Lamonthe and McCormick, 1973). The soluble sugar concentrations were determined using the Anthrone Reagent and absorbance was measured at 620nm (Sunderwirth et al., 1964). Pearson correlation analysis was used to determine the relationship among the biochemical constituents of cotton leaves and aphid numbers.

Results and Discussion

The two growing seasons differed considerably. The 1998 growing season provided above average temperatures and below average precipitation during the period of this study. The 1999 growing season was average for temperature. Rainfall was above average in May and June, but almost non-existent in July and August.

In order to normalize the data for nodal position and sampling time, boll age was used at each leaf position to characterize the physical and biochemical data. Specific leaf weights increased in the more water-stressed environments and increased both years as boll age increased. The amino acid concentration was highly variable during boll development

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between the two years. There was a trend toward higher amino acid concentrations ten days after pollination with a decreasing concentration during the latter half of boll development. The sugar concentrations were affected by water supply, but were highly variable across all boll ages and years, possibly due to the different sampling times at the different dates. Due to the four to five hour requirement to collect a series of leaf samples at each sampling the sugar concentration varied according to daily photosynthate production and export activity. The increased sugar concentration in leaves from more water-stressed environments was due to their inability to export the accumulating sugars. The variability in the data made interpretation difficult and restricted the value of ratios between amino acids and sugars.

In 1998, cotton aphid numbers remained relatively low (0-15 aphids per leaf) throughout the boll-filling period. Aphid numbers increased in young cotton in 1999, but beneficial arthropods rapidly eliminated them. At peak bloom, the aphid numbers were low (0-4 aphids per leaf) but by ten days after peak bloom aphid numbers began to increase (10-125 aphids per leaf); however, the cotton aphids could not be maintained because they were being effectively controlled by the resurgent beneficial arthropods.

Pearson correlation analyses were used to establish relationships between cotton aphids and leaf physical and biochemical characteristics (Table1). The amino acid concentration and aphids were negatively correlated (-0.16), but this was a weak relationship. There was a weak, negative correlation (-0.17) between the amino acid:sugar ratio and cotton aphids. Based upon two years of data across three water regimes each year, and very weak correlation's between the biochemical composition of leaves and cotton aphids, the results did not support the hypothesis of a relationship between biochemical composition of cotton leaves during boll development and changes in aphids. Cotton aphids may be more affected by events that change the external environment rather than the biochemical composition of leaves.

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Table 1. Pearson correlation analysis (r) of mean cotton aphid numbers per leaf to physical and biochemical compositon of cotton leaves, Terry County, Texas, 1998-1999.

	Specific Leaf Wt.	Sugar	Amino Acid	Amino Acid:Sugar Ratio
r	0.005	0.068	-0.159	-0.167
P	0.956	0.487	0.100	0.085

r measures direction and strength of the linear relationship between two continuous variables.
P significance correlation coefficient ($P \leq 0.10$), N=108.