Accumulation of Gossypol and Gossypol-like Pigments Associated with Defruited Cotton Plants

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A direct correlation was reported by Eaton & Rigler (6) between elevated carbohydrate concentrations in cotton root bark, caused by defruiting of plants, and resistance to *Phymatotrichum* root rot. The resistance incurred was attributed to the induction of higher levels of carbohydrates in the roots of otherwise highly susceptible cotton. Strains of cotton with inherently higher levels of total carbohydrates and those in which concentrations were increased by girdling stems are resistant to bacterial blight (*Xanthomonas malvacearum* [E. F. Sm.] Dows.) (4). Eaton & Ergle (5) noted that defruited cotton plants appeared to exhibit some resistance to *Verticillium* wilt. In other cases (1, and R. H. Garber, *personal communication*), days to initial expression of symptoms and severity of *Verticillium* wilt were not significantly altered by defruiting. However, disease expression was likely to occur more rapidly on plants having heavier boll loads (1). The discovery of other metabolites with similarly altered concentrations, associated with defruiting, may lead to a better understanding of resistance mechanisms.

Gossypol 2,2′-bis(8-formyl-1,6,7-trihydroxy-5-isopropyl-3-methylnaphthyl), a compound unique to the genus *Gossypium,* is toxic to nonruminant animals (2). Gossypol is toxic to the bollworm (*Heliothis zea*) and tobacco budworm (*Heliothis virescens*), and was suggested as a source of resistance in cotton to these pests (7). Introduction of conidia of *Verticillium albo-atrum,* sporangiospores of *Rhizopus nigricans,* cupric and mercuric ions, or various metabolic inhibitors into boll cavities or xylem vessels of excised stems induced gossypol synthesis in glanded and glandless Acala 4-42 (3). Levels of gossypol sufficient to inhibit spore germination and growth of *V. albo-atrum* and *R. nigricans* were induced. Consequently, it was suggested that gossypol be classified as a phytoalexin (3).

In an exploratory study, small, round, burnt-orange bodies were observed concentrated in the cambial region of cotton stems and roots of defruited plants. The bodies adhered to the wood and inner bark surface when the two were separated. This paper gives findings on the nature of the burnt-orange bodies, and on changes caused when plants were invaded by *Fusarium oxysporum* Schlecht. f. sp. *vasinfectum* (Atk.) Snyd. & Hans.

Plants from the cotton strains D4 (a Deltapine type) and A6 (an Acala type) were chosen. Treatments consisted of normal (fruited) and defruited plants inoculated with *F. oxysporum* f. sp. *vasinfectum* or *Xanthomonas malvacearum. Fusarium* inoculum was injected into the soil near the root system of the plants. Plants on which only two leaves had been inoculated with *X. malvacearum* were used as controls for comparison with those plants whose roots had been invaded by *F. oxysporum.* Plants were inoculated 25 days after removal of the first young fruit, and defruiting continued until plants were harvested at 20 weeks of age.

Root and stem sections were taken from each plant. The root section extended 20 mm up the main root from the position of the first major secondary root. The stem section was the adjacent 20 mm up the main stem. The bark was peeled from each section, and both the wood and bark components were retained. Since the burnt-orange bodies were distributed on the surface, measurements were made and the surface area was calculated. The bodies were dissolved by swirling each section of wood and its bark in 3 ml of 70% aqueous acetone for 45 sec. Two sets of samples were obtained. The acetone extracts from one set of samples were used to determine the μg of gossypol plus gossypollike pigments (G + GLP) per mm^2 of surface area (8). The second set of samples was used to determine μg of pure gossypol present (9). The difference between the two determinations was used to estimate the concentrations of gossypollike pigments.

The small, round, burnt-orange bodies were present in greater numbers in stem and root sections of defruited than in normal plants. The bodies were more concentrated in the root, less concentrated in the lower stem, and absent in the higher portions of the main stem of defruited plants of both cotton strains.

Concentrations of G + GLP in discrete bodies in the cambial region (Fig. 1) were higher in roots than in stems of normal and defruited strains. Accumulations of G + GLP were, however, greater in defruited than in normal plants. This increase in concentration due to defruiting was greater in strain A6, the increase being only slight in D4. When infected with *F. oxysporum* f. sp. *vasinfectum,* differences in accumulation of G + GLP revealed a differential response of cotton strains. Infection of normal plants resulted in an increase in levels of G + GLP in A6 and a decrease in D4. Changes in concentrations in roots were greater than those in stems. Compared with controls, infection of defruited plants led to a marked decrease in G + GLP concentration in A6, while G + GLP levels remained almost constant in D4.

Induced resistance to root pathogens associated with defruiting is attributed to increased levels of carbohydrates in roots (6). In view of the rising interest in gossypol and gossypollike pigments as a phytoalexin system, the accumulation of these compounds into discrete bodies in the cambial region of roots and stems of cotton plants is reported. The data are inadequate to

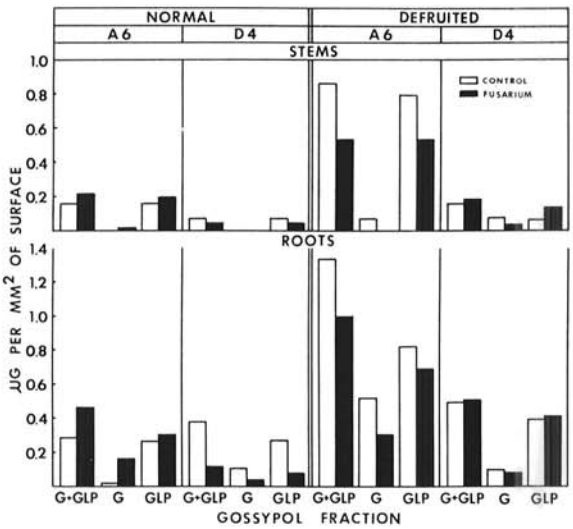

Fig. 1. Concentration of gossypol fraction in roots and stems of normal and defruited cotton strains inoculated with *Fusarium oxysporum* f. sp. *vasinfectum*.

determine whether the accumulation results from increased synthesis or from a shift in the translocation pattern.

The two strains used differ in their average degree of resistance to five major diseases. The differential response of these strains concerning G + GLP accumulation suggest a possible answer for these differences in resistance. However, the accumulation of G + GLP into discrete bodies in the cambial region will not explain the greater resistance to root pathogens of the D4 strain. One possible resistance mechanism suggested is a dispersal of G + GLP throughout the tissue of normal plants of D4 and defruited plants of A6 when invaded by *Fusarium*. Dispersal of these compounds throughout the root tissues could make them readily available to act as phytoalexins in response to root pathogens, whereas accumulation into discrete bodies could make them less available.

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