Aflatoxin Contamination: Variability and Management

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Abstract

Mapping aflatoxin contamination in the field reveals that most toxin occurs in relatively few, highly contaminated, bolls. Several studies suggest that protection of early bolls from pink bollworm damage will eliminate many of these highly contaminated bolls. Early harvest will also help reduce aflatoxin contamination. However, the crop must still be carefully managed after harvest because toxin content of mature bolls can increase very rapidly.

Introduction

Aflatoxin contamination of cottonseed is highly variable and this variability can be very frustrating for all involved with producing, marketing and utilizing cottonseed. Variability necessitates careful sampling to assess contamination and it makes the occurrence of aflatoxin seem mysterious. The information gathered over the past 20 years reduces the mystery and suggests some simple practices that will reduce the frequency and severity of aflatoxin contamination.

To get the best price, we want to produce cottonseed that can be fed to dairy cows and this requires the crop to have less than 20 parts per billion (PPB) of aflatoxin. In our laboratory we have studied the distribution of toxin in the Arizona crop for several years. Individual cotton locks often contain over 100,000 PPB and after ginning, an individual seed can contain over 500,000 PPB (2,6). This means one seed contains enough toxin to cause over 25,000 uncontaminated seeds to have an average toxin level above our 20 PPB goal. Relatively few bolls produce seeds which are highly contaminated. Eliminating these highly contaminated bolls needs to be a high priority in management of aflatoxin contamination of cottonseed.

In the last cotton report I discussed our studies on the incidence of toxin in pink bollworm damaged and non-damaged bolls. All of the highly contaminated locks (locks containing over 10,000 PPB of aflatoxin) were in bolls which had been damaged by pink bollworms. However, we know from our mapping of aflatoxin contaminated bolls on cotton plants that all PBW damaged bolls are not equally likely to become contaminated (Figure 1). Bolls formed towards the beginning of the season are most likely to be contaminated (3,8). This association of contamination with the early part of the crop was first noted by Lee Ashworth over fifteen years ago (1).

The following experiment, performed at the Yuma Valley Agricultural Center in 1988, illustrates the increased susceptibility of early bolls to aflatoxin contamination.

Materials and Methods

Cotton was planted at the Yuma Valley Agricultural Center near Yuma, Arizona in early March. The experiment had eight replicates each consisting of four rows of Deltapine (DP) 90 and four rows of DP 61. In mid-July 60 bolls (25 to 30 days old) and 60 flowers of each cultivar were tagged in each replicate. This allowed us to identify both the earliest formed bolls and bolls forming 3 to 4 weeks later. Tagged bolls were harvested at the end of October. After drying, the crop was subsampled and analyzed for aflatoxins. Pink bollworm control sprays were not initiated until a 30% infestation was reached.

Results

Thirty to 40 percent of the earlier tagged bolls were PBW damaged whereas 90 to 100 percent of the later bolls were damaged. The earlier bolls of both DP 90 and DP 61 produced seed which contained significantly more toxin than seed produced in later bolls. Average aflatoxin levels in the seed from earlier bolls was 8,452 PPB and 7,872 PPB, for DP 90 and DP 61, respectively. Aflatoxin levels in seed from bolls which formed 20 to 30 days later were 708 PPB and 2,040 PPB for DP 90 and DP 61. All differences between cultivars were not significant.

Discussion

Even though the earlier bolls in the above experiment had lower levels of PBW damage than the later formed bolls, and we know most aflatoxin occurs in PBW damaged bolls, the earlier bolls had more aflatoxin. Both Ashworth and Russell showed that bolls formed early in the season contain most of the crop's aflatoxin (1,8). We also know most aflatoxin occurs in PBW damaged bolls (2). Based on these observations we can conclude that prevention of pink bollworm damage to bolls formed in the beginning and middle of the season is an important step in preventing aflatoxin contamination.

Lee and Russell showed that the fungus which produces aflatoxins increases rapidly on the crop during the cotton season (5). This fungus, Aspergillus flavus, becomes closely associated with the crop and if the crop is exposed to dew, rain or high humidity, toxin levels can increase very rapidly. This occurs by both increases in toxin contents of seeds which had previously been infected during maturation (i.e. through PBW exit holes) and by new infections of the mature seed after boll opening (4). These increases may occur in mature seed in the field prior to harvest, in modules, in seed piles or even in the hands of the end user (4,17). We have found very high levels of the fungus on the crop in each of these circumstances. Therefore, each handler of the crop, from grower to user, must be vigilant to keep the crop low in toxins. Early harvest helps to prevent toxin increases in the field after boll maturity and also helps control PBW. Early harvest is, therefore, as important step in preventing aflatoxin contamination. Toxin contents can increase very rapidly when seed cotton is exposed to both spores of the fungus and high humidity after harvest (Figure 2). Proper handling precautions such as proper module construction and tarping of modules and seed piles are important components of a sound strategy to prevent unacceptable levels of aflatoxins in cottonseed.

Acknowledgments

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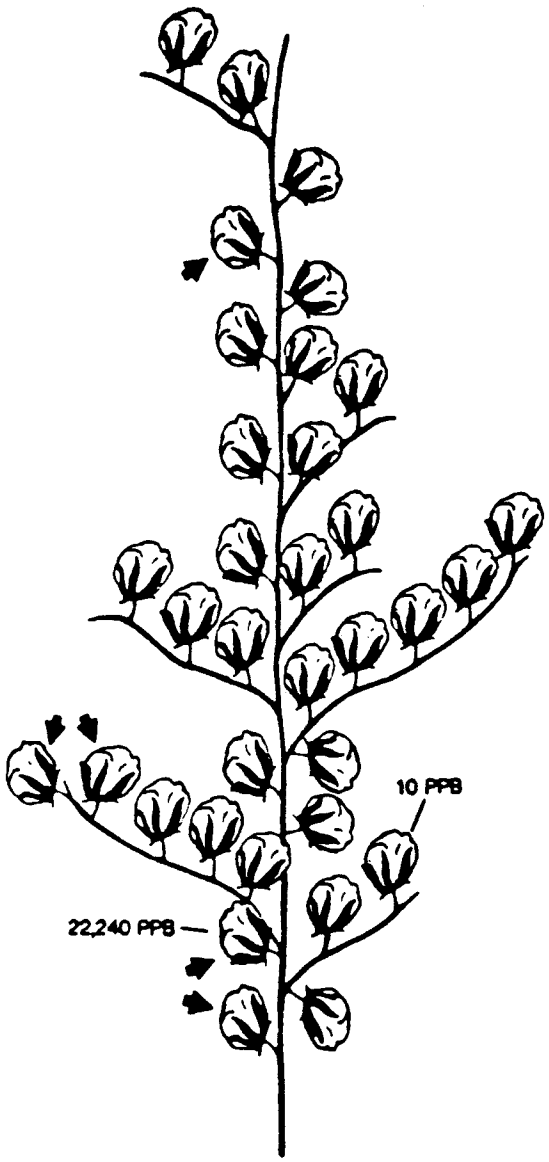

Figure 1. Distribution of aflatoxin contaminated cotton bolls on a cotton plant from a commercial field in the Yuma Valley. Modified from reference 3. The average level of aflatoxin in seed from this plant is 654 PPB (over 30 times our 20 PPB goal) and most of this toxin is from one boll. Only two bolls are contaminated. The arrows indicate bolls with pink bollworm exit holes.

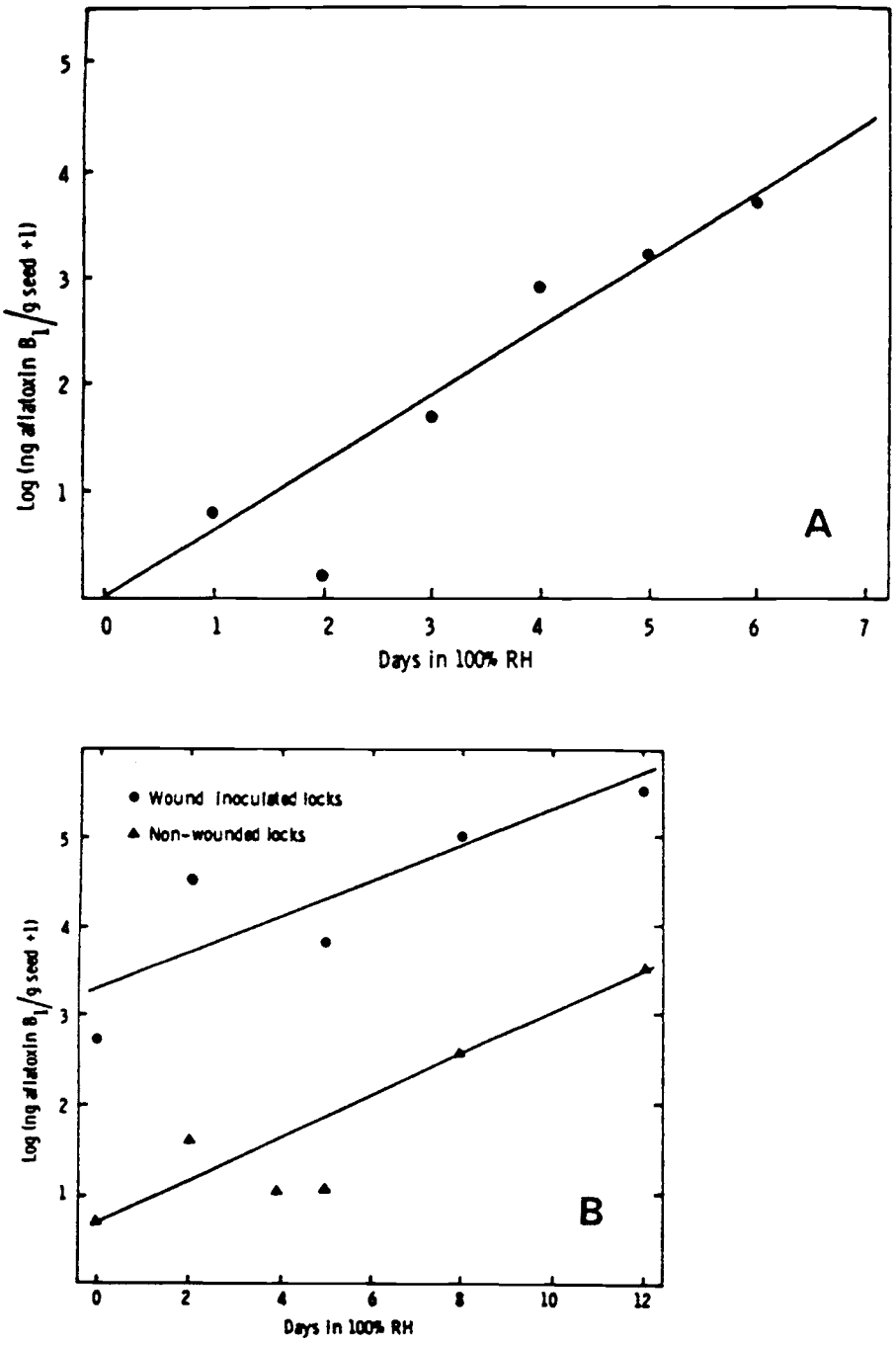

Figure 2. A. Greenhouse grown bolls were sprayed with spores of A. flavus and incubated at 100% relative humidity (RH). Toxin was detected after 1 day and toxin levels increased logarithmically. B. Toxin levels in bolls infected prior to incubation increased similarly. Bolls were inoculated prior to maturity; each boll had one wound inoculated lock and three non-wounded locks. Increases occurred over a broad temperature range. One ng/g equals one PPB. Data from reference 4.