Behind the Paper

Mycotoxin mayhem and corn earworm meddling in the middle

Plant defense is usually considered to play out at the level of individual plant-pest or plant-pathogen interactions. However, plant biotic interactions are complex and not always bipartite even in well-managed monoculture crop communities. Plant immunity is a culmination of co-evolutionary arms race between plants and their multiple attackers, and so, it comes with costs in addition to benefits (Pieters and Dicke, 2007). For example, the colonization by one pathogen can render the host plant vulnerable or resistant to another pathogen or pest.

Aspergillus flavus is an opportunistic fungal pathogen that causes preharvest ear rot. In addition to affecting crop yields, the fungus contaminates the seed with aflatoxins, the most carcinogenic natural compounds. Laboratory feeding studies show that aflatoxins are also toxic to insects (Zeng et al., 2006; Drott et al., 2017). *A. flavus* strains that produce the toxin may have a fitness advantage over non-producers, since the fungus lives predominantly in the soil (Drott et al., 2017). However, implications of these *A. flavus*-insect interactions during host plant colonization and mycotoxin contamination have not been fully investigated. In our recent maize field trials, we made a serendipitous observation that allowed us to explore and explain these multipartite interactions with supporting *in vitro* studies (Chalivendra et al., 2020; https://www.frontiersin.org/articles/10.3389/fpls.2020.565323/full, for details).

At its larval stage, corn earworm (CEW: *Helicoverpa zea* Boddie) is one of the major ear-feeding insect pests of maize. In two unrelated field trials, we observed a natural and heavy infestation of CEW occurring predominantly in *A. flavus* resistant maize lines. This was in contrast with very little damage seen in susceptible lines growing in adjacent rows of the same experimental plots. Despite CEW infestation, aflatoxin levels were low in resistant lines and high in susceptible lines. On the other hand, *A. flavus* resistant lines had greater seed fumonisins than the susceptible genotypes. Fumonisins are another class of mycotoxins mainly made by *Fusarium verticillioides* that often colonizes maize. Fumonisin contamination of maize is often associated with insect pressure and vectoring of fungal inoculum by chewing insects. Based on the inverse trend observed in CEW infestation and the accumulation of aflatoxins versus fumonisins, we hypothesized that *H. zea* may have differential sensitivity to the two mycotoxins. We tested the hypothesis by exposing CEW larvae to varying levels of each toxin mixed in a synthetic diet and found that aflatoxins are lethal to CEW at or above 250 ppb, while fumonisins are tolerated even at 100 ppm (***Fig. 1***). Taken together, our work suggests that mycotoxins can add another layer to the complexity of host-pathogen-insect pest interactions.

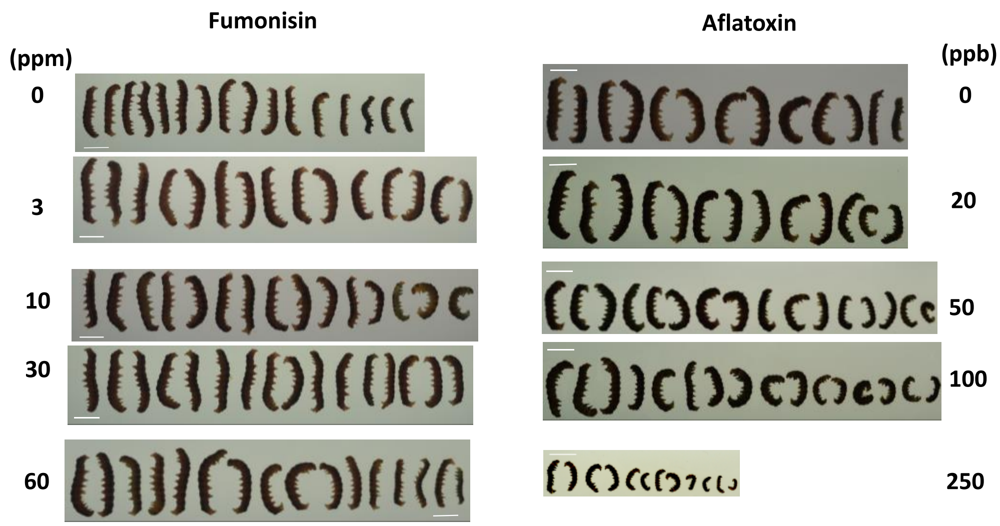

***Fig. 1*. Effects of aflatoxin B_1 and fumonisin B_1 on the growth and mortality of *H. zea* larvae**.

How can this knowledge be used to improve plant health and food safety? Can we still take advantage of the entomopathogenicity of *A. flavus* without foregoing food safety and security? The answers may not be immediately available. However, there are potential pathways that can be explored. Non-aflatoxigenic *A. flavus* strains can also kill insects that infest crops (Kenneth Damann, personal communication). In fact, *A. flavus* makes several other anti-insectan compounds in addition to aflatoxins, although their effects on human and animal physiology are yet to be explored. As a necrotrophic pathogen, *A. flavus* uses specific secondary metabolites other than aflatoxins to kill and feed on plant hosts (e.g., Chalivendra et al., 2017). Silencing the production of phytotoxins may offer an opportunity to restrain the fungus in the soil and take advantage of its virulence on insects that damage crops.

References

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