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# Host Plant Matters: How Crop Choice Influences Insecticide Susceptibility of Fall Armyworm

*Mude Pavan Kalyan[1], Venkateswarlu, U[2] and Gaurav Vinod Rao Sadafale[3]
[1]Ph.D Scholar, Department of Entomology, S.V. Agricultural College, Tirupati, Acharya N.G. Ranga Agricultural University, Guntur, Andhra Pradesh, 517502, India
[2]Assistant Professor (Entomology), Polytechnic of Agriculture, Tirupati 517502, Acharya NG Ranga Agricultural University, Lam, Guntur, Andhra Pradesh, India
[3]Ph.D Scholar, Department of Entomology, Post Graduate Institute, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra, 413722, India
*Corresponding Author's email: pavannaickmude@gmail.com

The fall armyworm, *Spodoptera frugiperda* (J. E. Smith), is a highly polyphagous and destructive pest of maize and several other crops. Its management is becoming increasingly difficult because of its rapid adaptation and declining susceptibility to several insecticides. Recent research has revealed an important but often overlooked factor influencing insecticide performance: the host plant on which the insect develops. Different host plants can alter the activity of detoxification enzymes and the expression of genes involved in xenobiotic metabolism, thereby changing insecticide susceptibility. Particularly strong host-associated differences have been observed for tetraniliprole. Understanding the interaction between host plants, insect physiology and insecticide toxicity can strengthen resistance management and improve sustainable fall armyworm control.

**Keywords:** Fall armyworm, *Spodoptera frugiperda*, host plant, insecticide susceptibility, insecticide resistance, detoxification enzymes, UGT40F3, integrated pest management

## Introduction

The fall armyworm, *Spodoptera frugiperda*, has emerged as one of the most important insect pests threatening maize production in many parts of the world. Its success as an invasive pest is closely associated with its remarkable adaptability, high reproductive capacity, strong dispersal ability and broad host range. Unlike insects restricted to a single crop, fall armyworm can feed on numerous cultivated and wild plants, allowing populations to survive and move continuously across agricultural landscapes. This ability to shift between hosts makes its management particularly challenging. Chemical insecticides continue to play an important role in fall armyworm management, especially when larval populations become economically damaging. However, intensive and repeated insecticide use has increased concerns regarding resistance development. Reduced susceptibility has already been reported against several insecticide groups, and resistance management has consequently become an essential component of modern fall armyworm control. Resistance is not caused by a single mechanism. It may involve changes at the insecticide target site, reduced penetration, behavioural responses and, importantly, enhanced metabolic detoxification. An emerging aspect of this problem is the role of the host plant. The plant on which a larva develops is not merely a source of food. Plants contain a wide range of defensive chemicals that can influence insect physiology and stimulate detoxification systems. Consequently, larvae developing on different plants may enter an insecticide-treated crop with different physiological capacities to tolerate chemical stress. Recent research has provided compelling evidence that host-plant adaptation can influence insecticide susceptibility in fall armyworm.

## Fall Armyworm and Its Remarkable Host Range

Fall armyworm is a highly polyphagous noctuid moth capable of utilizing a wide diversity of host plants. Maize is one of its most important hosts, but the insect can also develop on sorghum, rice, wheat, barley, pearl millet and numerous grasses and non-cereal plants. This broad host range gives the insect considerable ecological flexibility. When one crop becomes unsuitable because of harvesting or environmental conditions, the pest can survive on alternative crops or weeds and subsequently recolonize susceptible crops. Host switching is therefore an important component of fall armyworm ecology. A population developing on maize may differ physiologically from one developing on sorghum, sesame, groundnut or a grass species. These differences can arise because plants vary in nutritional quality and in the types and concentrations of defensive compounds they produce. The insect must continuously adjust its digestive and detoxification machinery to cope with these differences. This physiological flexibility is particularly important in a generalist herbivore and may have consequences that extend beyond plant adaptation. The biochemical mechanisms that allow an insect to tolerate plant defensive chemicals may also provide some protection against synthetic insecticides.

## The Hidden Link Between Host Plants and Insecticide Resistance

Insecticide resistance is commonly viewed as a consequence of repeated exposure to pesticides. While insecticide selection is undoubtedly a major evolutionary force, resistance can also be influenced by pre-existing physiological adaptations associated with host plants. This concept has received increasing attention in studies of polyphagous herbivores. Plants produce secondary metabolites that can be toxic or deterrent to herbivorous insects. To survive, insects rely on detoxification systems that transform these compounds into less harmful products or facilitate their elimination. Major components of this defence system include cytochrome P450 monooxygenases, glutathione S-transferases, esterases, carboxylesterases, UDP-glycosyltransferases and ABC transporters. The important point is that these biochemical pathways are not always highly specific. Enzymes that metabolize plant-derived chemicals may also metabolize synthetic compounds. Thus, adaptation to a chemically defended host plant can potentially provide an unintended advantage when the insect encounters an insecticide. This phenomenon has been described as a link between host-plant adaptation and pesticide resistance. Similar relationships have been reported in other herbivorous insects, including *Tetranychus urticae*, *Spodoptera litura* and several aphid species.

## Evidence from Different Host Plants

A recent study published in the *Journal of Pest Science* provides particularly valuable evidence for fall armyworm. Researchers examined populations maintained on 12 host plants, including maize, rice, wheat, barley, sorghum, pearl millet, *Zizania latifolia*, perennial ryegrass, *Echinochloa crus-galli*, groundnut, sesame and castor. The study compared insecticide susceptibility among larvae associated with these different hosts. The researchers evaluated eight insecticides representing different modes of action. The results demonstrated that susceptibility was not uniform across host-associated populations. Instead, the insecticide response varied according to the plant on which larvae had developed. The clearest differences were observed with tetraniliprole. Compared with the maize-fed population, larvae associated with wheat, sorghum, *Echinochloa crus-galli*, sesame, pearl millet and perennial ryegrass exhibited increased resistance. The resistance ratios were approximately 26.3-fold in wheat, 5.50-fold in sorghum, 3.33-fold in *E. crus-galli*, 2.67-fold in sesame, 2.00-fold in pearl millet and 1.83-fold in perennial ryegrass. These results are particularly important because they demonstrate that host-plant history can produce substantial differences in insecticide susceptibility even within the same pest species. The observation does not mean that a particular crop will always produce resistant insects, but it shows that host-associated physiological variation can contribute to differences in insecticide performance.

## Detoxification Enzymes: The Insect's Biochemical Shield

The major explanation for host-associated differences appears to be changes in detoxification capacity. The study found that host plants influenced the activity of several important enzyme systems. P450 activity increased in larvae associated with several alternative hosts, including pearl millet, *Zizania latifolia*, perennial ryegrass, groundnut, sesame and castor. GST and UGT activities also varied among host-associated populations, while esterase and carboxylesterase activity showed distinct host-dependent patterns. These enzymes can be considered part of the insect's biochemical shield. When larvae consume plants containing defensive chemicals, their detoxification systems become important for survival. If those same enzymes can process an insecticide, the insect may become less susceptible to that insecticide. This mechanism helps explain why insecticide susceptibility should not always be considered a fixed characteristic of a pest population. It can be influenced by the insect's physiological history, including the host plant on which it developed.

## Not All Insecticides Respond in the Same Way

An important finding from the study is that host-plant effects were not identical for all insecticides. Increased resistance to metaflumizone occurred in populations associated with several alternative hosts, while higher chlorantraniliprole resistance was observed in larvae associated with castor, sesame and groundnut. Lufenuron resistance also increased in some host-associated populations. In contrast, susceptibility to some insecticides remained relatively stable across hosts, and certain host plants were even associated with increased susceptibility to particular compounds. This indicates that host-plant adaptation does not automatically produce broad-spectrum insecticide resistance. The outcome depends on the interaction between the chemical characteristics of the host plant, the insect's detoxification system and the biochemical properties of the insecticide. Therefore, it would be inappropriate to conclude that larvae feeding on one particular crop will always be more resistant to every insecticide. Instead, the research highlights the complexity of insect–plant–insecticide interactions.

## Why Alternative Hosts and Weeds Deserve Attention

The presence of alternative hosts around agricultural fields may have important consequences for fall armyworm management. Grasses and other weeds can provide shelter and food when the main crop is unavailable or less suitable. *Echinochloa crus-galli*, for example, was included among the host plants evaluated in the recent study and was associated with altered insecticide susceptibility. This does not mean that every weed must be removed indiscriminately. Rather, weed management should be incorporated into a broader IPM strategy. Understanding which weeds serve as important fall armyworm hosts can help identify potential pest reservoirs and reduce opportunities for continuous survival and movement between crops. Host switching may be especially important in diversified agricultural landscapes where maize is grown alongside sorghum, millet, vegetables and other crops. The pest may move between these hosts, experiencing different plant chemicals and physiological conditions before reaching the crop where insecticide treatment is applied.

## Implications for Farmers and Pest Managers

The practical message emerging from this research is that insecticide performance should be interpreted in the context of pest biology and cropping systems. If insecticide control is poor, simply increasing the dose is not necessarily the correct solution. Poor control can result from several factors, including late application, large larval size, inadequate spray coverage, unsuitable environmental conditions, inappropriate insecticide selection or resistance. Farmers should therefore follow recommended doses and application timings and avoid repeated use of insecticides with the same mode of action. Rotation among effective insecticide groups, combined with monitoring of field populations, is essential for slowing resistance development. Crop and weed conditions around the field should also receive greater attention. Populations developing on alternative hosts may have different physiological characteristics from those continuously feeding on maize. Although host history alone cannot be used to predict resistance in a field population, it can provide useful ecological context for resistance monitoring.

## Host-Plant Information in Integrated Pest Management

Integrated pest management provides the most appropriate framework for incorporating these findings. Fall armyworm should be monitored regularly, particularly during early crop growth when young larvae are establishing in maize. Agronomic practices, biological control, conservation of natural enemies and appropriate weed management can reduce pest pressure and minimize dependence on insecticides. Chemical control remains valuable when pest populations reach damaging levels, but insecticides should be used carefully and strategically. Repeated exposure to the same mode of action creates strong selection pressure and can accelerate resistance evolution. The emerging evidence on host plants adds a new dimension to this strategy. Resistance management should increasingly consider not only which insecticide is used and how frequently it is applied, but also the ecological environment in which the pest population develops.

## Future Prospects

The relationship between host plants and insecticide susceptibility opens exciting opportunities for future pest-management research. Molecular markers associated with detoxification pathways could eventually contribute to rapid resistance-risk assessment. Genes such as UGT40F3 may become useful indicators of physiological adaptation, although further validation under field conditions is necessary. Future studies should also examine sequential host switching rather than populations maintained continuously on a single plant. In real agricultural landscapes, fall armyworm frequently moves among maize, sorghum, grasses and other crops. Such movements may produce more complex interactions among plant chemicals, detoxification enzymes and insecticide susceptibility than those observed under controlled laboratory conditions. A better understanding of these interactions could ultimately lead to more precise resistance-management programmes in which host-plant ecology, insect physiology and pesticide use are considered together.

## Conclusion

The fall armyworm is a highly adaptable pest, and its ability to utilize diverse host plants has consequences that extend beyond survival and development. Evidence now shows that host plants can influence insecticide susceptibility by altering detoxification enzyme activity and the expression of genes involved in xenobiotic metabolism. The strong differences observed for tetraniliprole, together with the involvement of UGT40F3, demonstrate a clear biochemical connection between host-plant adaptation and insecticide response. These findings emphasize that insecticide resistance is not simply a consequence of pesticide exposure; it can also be influenced by the ecological and physiological history of the insect. For sustainable fall armyworm management, farmers and pest managers should therefore integrate crop and weed management, insecticide rotation, field monitoring, biological control and resistance-management practices. Understanding the three-way interaction among host plant, insect physiology and insecticide will be increasingly important for developing effective and environmentally responsible pest-management strategies.

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