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Review Paper

A Review on Fall Armyworm (*Spodoptera frugiperda*) Insecticide Resistance

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ABSTRACT

The commonly known fall armyworm (*Spodoptera frugiperda*) is an important pest of corn, cotton, and other crops in the Americas, Africa, and Asia. The species is native to tropical and subtropical regions of the Americas, but it has spread to other parts of the world in recent years. The pest has a wide host range, including important crops like corn, cotton, rice, sorghum, and vegetables. Large populations of fall armyworms can cause significant damage to crops, leading to reduced yields and lower crop quality. The threat of insecticide resistance in *S. frugiperda* is a growing concern for agricultural production and food security. Insecticides are an important tool for managing fall armyworm populations, but the development of resistance to these chemicals has become a major issue in many regions. This pest has shown resistance to several classes of insecticides, including pyrethroids, organophosphates, and carbamates. To effectively manage insecticide resistance in *S. frugiperda* populations, it is important to consider these factors and develop integrated pest management strategies that take them into account. This may include the use of alternative control methods, such as biological control and cultural control, and the judicious use of insecticides to minimize selection pressure for resistance development. It is important for farmers, researchers, and policymakers to work together to develop and implement integrated pest management strategies that can effectively manage *S. frugiperda* populations while minimizing the development and spread of insecticide resistance.

Keywords: Fall Armyworm, Spodoptera frugiperda, Insecticide Resistance

INTRODUCTION

Spodoptera frugiperda, commonly known as the fall armyworm, is an important pest of corn, cotton, and other crops in the Americas, Africa, and Asia. The species is native to tropical and subtropical regions of the Americas, but it has spread to other parts of the world in recent years. The fall armyworm has a wide host range and can feed on more than 80 plant species, including important crops like corn, cotton, rice, sorghum, and vegetables. Adult fall armyworms (Figure 1) are moths that lay eggs on plant leaves, and the larvae that hatch from these eggs feed on the leaves, stems, and reproductive structures of plants (Figure 2). Large populations of fall armyworms can cause significant damage to crops, leading to reduced yields and lower crop quality. The species has become a major pest in many parts of the world in recent years, and the spread of the pest has been facilitated by human activities, including trade and transportation.[1–6]

Figure 2. Adult male of *Spodoptera frugiperda* [7]

The control of fall armyworm populations relies on a variety of management strategies, including the use of insecticides, cultural practices, and biological control methods. Insecticides are an important tool for managing fall armyworm populations, but the development of resistance to these chemicals has become a major concern in many areas. The development of integrated pest management strategies that incorporate multiple control methods is essential for effectively managing fall armyworm populations and minimizing the development of insecticide resistance.[1,8,9]

Figure 2. Fifth instar larva of *Spodoptera frugiperda* [7]

The spread of the fall armyworm to new regions and its ability to develop resistance to insecticides have heightened concerns about its impact on agriculture. Insecticides are a key tool in managing fall armyworm populations, but the development of resistance to these chemicals has become a major concern in many areas. The development of integrated pest management strategies that incorporate multiple control methods is essential for effectively managing fall armyworm populations and minimizing the development of insecticide resistance. Given the importance of *S. frugiperda* as an agricultural pest, there is a need for continued investment in research and development to improve our understanding of the pest and to develop more sustainable and effective methods for controlling it. This will be critical to ensure global food security and support the livelihoods of farmers who rely on these crops for their income.[3,4,10]

THE THREAT OF INSECTICIDE RESISTANCE IN FALL ARMYWORM

The threat of insecticide resistance in *S. frugiperda* is a growing concern for agricultural production and food security. The pest has a wide host range and is capable of causing significant damage to crops, which can lead to economic losses for farmers and food shortages for consumers. Insecticides are an important tool for managing fall armyworm populations, but the development of resistance to these chemicals has become a major issue in many regions. This pest has shown resistance to several classes of insecticides, including pyrethroids, organophosphates, and carbamates. This has been observed in different regions of the world, and the prevalence and degree of resistance can vary depending on the specific population and the history of insecticide use in the area. The development of resistance can be attributed to several factors, including the overuse and misuse of insecticides, the genetic variability of the pest, and the selection pressure imposed by insecticide use.[8,10–12]

The development of insecticide resistance in *S. frugiperda* has important implications for agricultural production and food security. It can lead to increased pesticide use, which can have negative environmental impacts and increase the cost of production for farmers. Resistance can also reduce the effectiveness of insecticide treatments, making it more difficult to manage fall armyworm populations and leading to reduced crop yields and quality. Effective management of *S. frugiperda* populations requires a multi-faceted approach that includes the use of integrated pest management strategies that incorporate multiple control methods. This can include cultural practices, such as crop rotation and the use of resistant crop varieties, as well as biological control methods and the judicious use of insecticides. Continued research and development are needed to improve our understanding of the biology and ecology of *S. frugiperda* and to develop more sustainable and effective methods for controlling this important pest.(10,12,13)

MECHANISMS OF INSECTICIDE RESISTANCE IN FALL ARMYWORM

The development of insecticide resistance in *S. frugiperda* is a complex process that involves various mechanisms. These mechanisms can be broadly categorized into three types: target site resistance, metabolic resistance, and behavioral resistance. Target site resistance occurs when mutations in the target site of an insecticide prevent the insecticide from binding effectively, thus reducing its toxic effects. In this pest, target site resistance has been observed in the voltage-gated sodium channel, which is the target site for pyrethroid insecticides. Mutations in this channel can alter its structure and reduce the ability of pyrethroids to bind to it, leading to resistance. Metabolic resistance occurs when insects develop mechanisms to detoxify or eliminate insecticides from their bodies. This can occur through the upregulation of enzymes such as cytochrome P450s, esterases, and glutathione S-transferases, which can break down or modify insecticides. In *S. frugiperda*, metabolic resistance has been observed for several insecticide classes, including organophosphates and carbamates. Behavioral resistance occurs when insects modify their behavior to avoid exposure to insecticides. This can occur through a range of mechanisms, including altered feeding patterns, migration to different areas, or changes in mating behavior. In *S. frugiperda*, behavioral resistance has been observed in response to insecticides such as Bacillus thuringiensis (Bt), which can reduce feeding on treated crops.(11,14–20)

The mechanisms of insecticide resistance in fall armyworms can vary depending on the insecticide class and the local selection pressure. For example, pyrethroid resistance is more commonly observed in areas where pyrethroids are heavily used, while organophosphate resistance is more commonly observed in areas where these insecticides are still in use. Understanding the mechanisms of resistance is critical for developing effective resistance management strategies that can slow or prevent the spread of resistance in this pest populations.(12,15–18)

FACTORS CONTRIBUTING TO THE DEVELOPMENT OF RESISTANCE

Several factors contribute to the development of insecticide resistance in *S. frugiperda* populations. Some of the key factors include: (1) Intensive use of insecticides; (2) Genetic variability; (3) Cross-resistance; (4) Overlapping generations; (5) Migration; dan (6) Agricultural practices.

Intensive use of insecticides for *S. frugiperda* control can create a strong selection pressure for the development of resistance in populations. The use of insecticides can kill susceptible individuals, but resistant individuals can survive and reproduce, leading to the emergence of resistant populations. Regarding genetic variability, this pest populations can have a high degree of genetic variability, which can influence the development and spread of resistance. Genetic differences between individuals can affect their susceptibility to insecticides, and resistant individuals may have a genetic advantage that allows them to survive and reproduce. Cross-resistance occurs when resistance to one insecticide confers resistance to other insecticides with a similar mode of action. For example, resistance to pyrethroids can also confer resistance to other insecticides that target the sodium channel, such as organochlorines and dichlorodiphenyltrichloroethane (DDT). Regarding overlapping generations, *S. frugiperda* has multiple overlapping generations per year, which can increase the speed at which resistance develops. Resistant individuals can pass on their resistance genes to their offspring, leading to a rapid increase in resistance within a population.[21–27]

S. frugiperda is capable of long-distance migration, which can contribute to the spread of resistance. Resistant individuals can migrate to new areas and introduce resistance genes into susceptible populations, leading to the rapid spread of resistance. Certain agricultural practices, such as monoculture and the use of high-input cropping systems, can contribute to the development of resistance in fall armyworm populations. These practices can increase the reliance on insecticides for pest control, leading to increased selection pressure for resistance development.[8,28–31]

To effectively manage insecticide resistance in *S. frugiperda* populations, it is important to consider these factors and develop integrated pest management strategies that take them into account. This may include the use of alternative control methods, such as biological control and cultural control, and the judicious use of insecticides to minimize selection pressure for resistance development. Regular monitoring of resistance levels can also help to identify emerging resistance and guide management decisions.[19,32,33,35]

CONCLUSION

Overall, the development of insecticide resistance in *S. frugiperda* populations has significant implications for agricultural production and food security. It is important for farmers, researchers, and policymakers to work together to develop and implement integrated pest management strategies that can effectively manage this pest populations while minimizing the development and spread of insecticide resistance. The management of insecticide resistance in fall armyworms requires a multi-faceted approach that incorporates a combination of chemical and non-chemical control methods, as well as monitoring and education efforts. Continued research and development are also critical for developing new and innovative control strategies to manage this important pest.

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