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Unveiling the effectiveness of *Beauveria bassiana* as a biocontrol agent against adult hoppers: A Review

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Abstract

This review explores the efficacy of *Beauveria bassiana* as a biocontrol agent targeting adult hoppers, crucial pests in agriculture. *B. bassiana*, a fungal entomopathogen, shows promising potential due to its eco-friendly nature and specificity in targeting hoppers. Through a comprehensive analysis of existing literature, this review elucidates the mechanisms underlying its effectiveness, including infection dynamics, host specificity, and environmental factors influencing efficacy. Key findings highlight the significant impact of *B. bassiana* on hopper populations and its potential as a sustainable alternative to chemical pesticides. The synthesis of current knowledge aims to guide further research and application of *B. bassiana* in integrated pest management strategies.

Keywords: *Beauveria bassiana*, biocontrol agent, adult hoppers, entomopathogenic fungi, integrated pest management

Introduction

A facultative cosmopolitan entomopathogen with an incredibly wide host range is *Beauveria bassiana*, the anamorph stage of *Cordyceps bassiana*. discovered by Agostino Bassi de Lodi initially (Keswani et al., 2013). The most well-liked endophytic fungal entomopathogen to date is *B. bassiana*, which is widely available commercially as a strong mycopesticide. With the use of inoculation techniques including soil drenches, seed coatings and immersions, radicle dressings, root or rhizome immersions, stem via injection, and leaf and flower sprays, the fungus establishes himself as an endophyte naturally, for example, by stomatal penetration. It is therefore well recognized as successful in a range of plants, including grasses; agricultural crops, such as tomato, cotton, corn, and potato; the medicinal group, which includes coffee, cocoa and opium poppy and trees, such as West Virginia White Pine and *Carpinus caroliniana* (Vega et al., 2008).

In recent years, the escalating demand for sustainable and environmentally friendly pest management strategies has intensified the exploration of biological control agents. Among these, *B. bassiana*, a ubiquitous entomopathogenic fungus, has emerged as a promising candidate for controlling various agricultural pests. Its efficacy against adult hoppers, notorious for inflicting significant damage to crops worldwide, has garnered substantial attention from researchers and practitioners alike. The exploration of *B. bassiana's* biocontrol potential against adult hoppers represents a critical area of study, driven by both ecological and economic imperatives. As conventional chemical pesticides face increasing scrutiny due to their adverse environmental impacts and the development of pest resistance, the search for alternative methods has become imperative. Consequently, elucidating the effectiveness of *B. bassiana* offers a pathway towards sustainable pest management practices, aligning with the principles of integrated pest management (IPM) and ecological sustainability. Numerous research studies have contributed

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to unraveling the biocontrol potential of *B. bassiana* against adult hoppers across diverse agricultural systems and geographical regions. For instance, studies by (Lacey et al., 2015) and (Jenkins et al., 2018) have demonstrated the efficacy of *B. bassiana* formulations in controlling populations of adult hoppers, resulting in significant reductions in pest abundance and crop damage. These findings underscore the practical utility of *B. bassiana* as a viable alternative or complement to chemical pesticides in hopper management programs.

Having a solid grasp of the physiology of the natural parasites of insects is crucial, since they constitute the biggest group of animals and inflict significant damage in forest management. Among these natural parasites are fungi that are entomopathogenic. These belong to several systematized groupings and are a heterogeneous group with different biological characteristics. When it comes to insects and other arthropods, most entomopathogenic fungi are harmful. These are more successful in infecting their host, which means they can control the number of dangerous insects, such as pests found in forests (Dara et al., 2019). Moreover, the mechanisms underlying *B. bassiana's* pathogenicity and its interactions with hopper populations have been elucidated through molecular and ecological studies. Research by (F. Fang et al., 2019) and (H. Wang et al., 2020) has provided valuable insights into the genetic diversity of *B. bassiana* strains, their virulence factors, and their impact on hopper physiology and behavior. Such knowledge not only enhances our understanding of the biocontrol process but also facilitates the optimization of *B. bassiana*-based formulations for enhanced efficacy and environmental compatibility.

Figure 1: Life Cycle of *Beauveria bassiana*

General Characteristics of *Beauveria Bassiana*

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Beauveria bassiana is a naturally occurring fungus that causes white muscardine illness by acting as a parasite on different types of arthropods. It is classified as an entomopathogenic fungus. To treat a variety of pests, such as termites, thrips, whiteflies, aphids, and different beetles, it is employed as a biological insecticide. Its potential application in managing bed bugs and mosquitoes that carry malaria is being researched (Barbarin et al., 2012). A species complex of closely related isolates with comparable morphologies has long been known by the name *B. bassiana*. According to (Rehner & Buckley, 2005), *B. bassiana* is made up of numerous discrete lineages that should be acknowledged as separate phylogenetic species. In 2011, the genus Beauveria was renamed with a proposed type for *B. bassiana* (Rehner et al., 2011).

When *B. bassiana* is cultivated in culture, it forms a white mold that yields white spore balls composed of many haploid, single-celled, hydrophobic conidia. The rachis, a narrow apical extension of the small, ovoid conidiogenous cells that create the conidia, elongates into a long, zigzag extension (Keerthi et al., 2022). Termites, whiteflies, and a variety of other insects can be managed with *Beauveria bassiana* as a biological insecticide. Its use to the management of mosquitoes that transmit malaria is being studied (McNEIL Jr, 2005). The spores are sprayed as an emulsified suspension or wettable powder on the afflicted crops, or they can be applied to mosquito nets as a mosquito control agent.

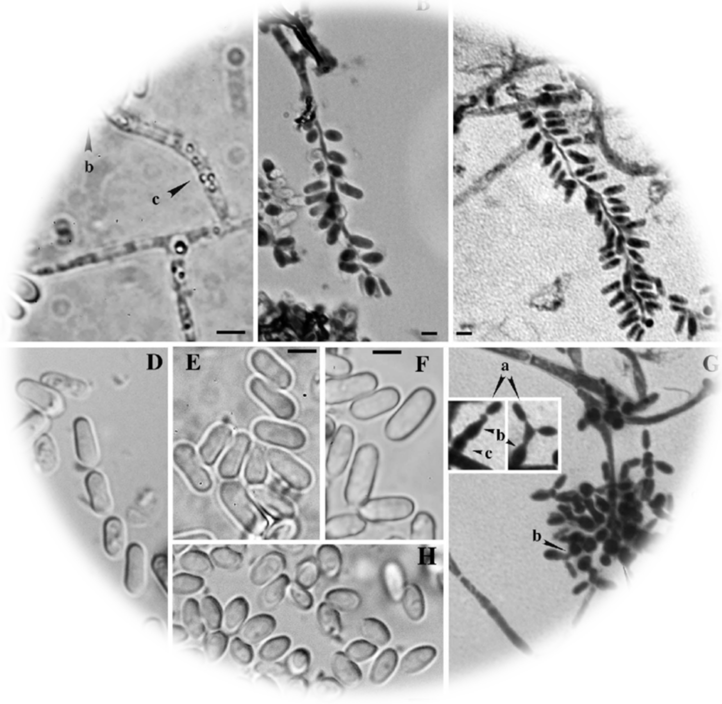

Figure 2: Microscopic view of *Beauveria bassiana*

Beauvericin exhibits potent antibacterial activity against pathogenic bacteria that affect humans, animals, and plants, without any discernible difference between Gram-positive and Gram-negative bacteria. Unlike other fungal antibiotics, beauvericin acts on the bacterial cell organelles & enzyme system rather than the peptidoglycan cell wall production. Beauvericin may be able to help find treatments for nonfood crop diseases, antibiotic resistance, and fatal bacterial infections due to its broad-spectrum antibacterial action (Z. Wang et al., 2012).

As a metabolite of fungi, beauvericin is inactive as an antifungal agent. But when beauvericin is combined with another substance, a whole new avenue for its development and application in biological activity is revealed. For example, when administered together, beauvericin and ketoconazole combat Candida parapsilosis, one of the main causes of infant mortality, yet when given separately, neither drug has much of an impact on this fatal fungus (L. Zhang et al., 2007).

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The entomopathogenic *B. bassiana* is a saprobe and endophyte that consists of a variety of infectious propagules, including submerged and aerial conidia, in vitro single-cell blastospores, and hyphal bodies, which are in vivo insect hemolymph-derived cells. The spore-coat hydrophobins mediate the nonspecific hydrophobic interactions that form an adhesive interface between the conidial appear or the insect epicuticle, which initiates the pathogenic process. The hydrophobin genes, hyd1 and hyd2, are found in *B. bassiana* and are in charge of adhesion, pathogenicity, spore thermotolerance, and the creation of the rodlet layer, a protective spore-coat structure (S. Zhang et al., 2011).

Insect cuticle serves as the major defense against pathogen invasion and is mostly made of chitin that is embedded with proteins. To break down the cuticle of insects, *B. bassiana* generates proteases and chitinases. In *B. bassiana*, 2 chitinases (Bbchit1 and Bbchit2) that lack a chitin-binding domain have been identified. But hybrid Chitin-binding domains sourced from bacteria, plants, or insects were fused to Bbchit1 to create chitinases. After *B. bassiana* was modified to carry the hybrid chitinase gene, the altered strains demonstrated increased virulence, which resulted in 23% less time needed to kill the intended insects (W. Fang et al., 2005).

Mechanisms of Action and Biocontrol Properties

B. bassiana is a remarkable entemopathogenic fungus because it produces a wide variety of chemically varied secondary metabolites. *Bassianin, tenellin, beauvericin, bassianolide*, and cyclosporin A are the main secondary metabolites that *B. bassiana* produces (Keswani et al., 2013). *B. Bassiana* invades insect hosts by using a variety of infection techniques. The significance of adhesion factors & enzymatic activities in promoting host penetration as well as colonization was shown by studies conducted by (Y. Wang et al., 2019).

The biocontrol activity of *B. bassiana* is significantly influenced by the secondary metabolites it produces. Numerous compounds with insecticidal qualities, such as beauvericin or bassianolide, which interfere with insect physiological functions, have been found by (Enders & Begcy, 2021). Conidia from *B. bassiana* attach themselves to the host's cuticle to infect insects. As the conidia sprout, hyphae are produced that pierce the cuticle and multiply throughout the insect's body. Systemic fungal development results from this invasion, which eventually kills the host by destroying tissue and depleting nutrients (de Faria & Wraight, 2007). Secondary compounds with cytotoxic and insecticidal properties, which include beauvericin, bassianolide, including oosporein, are secreted by *B. bassiana*. By interfering with physiological functions in the host, such as ion transport and cell membrane integrity, these substances increase the virulence of the fungus (Vey et al., 2001). *B. bassiana* causes the host to produce antimicrobial peptides, phenoloxidases, along with reactive oxygen species as part of its immunological response. These immune components try to stop the fungal invasion, but they frequently fall short and allow the host to become infected throughout their body, which ultimately results in death (Lu & Leger, 2016).

B. bassiana has the ability to form endophytic relationships with plants, offering protection from insects that feed on herbivores. By producing toxic compounds and colonizing the plant's vascular system, the fungus prevents insects from feeding on and depositing eggs. In agricultural contexts, this endophytic lifestyle strengthens plant defense mechanisms and encourages ecological sustainability (Akutse et al., 2013).

Global integrated pest management (IPM) initiatives have made great use of the biocontrol capabilities of *B. bassiana*. It is a useful tool for sustainable pest control tactics because to its efficiency against a wide range of insect pests, such as Lepidoptera, Coleoptera, Diptera, and Hemiptera (Lacey et al., 2015).

Moreover, *B. bassiana* shows compatibility with chemical pesticides and other biological control agents, enabling integrated approaches that maximize pest suppression while minimizing

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environmental effects. Its adaptability for sustainable pest management techniques is further enhanced by its low toxicity to non-target organisms and capacity to endure in a variety of ecological settings (Gregoire & Gould, 2023).

There has been some clarification regarding the biochemical or genetic factors that influence the hydrocarbon assimilation routes in entomopathogenic fungus. When radiolabeled hydrocarbons were used to investigate the metabolic processes of *B. bassiana's* alkane catabolic pathways, a degradative pathway was discovered. Cytochrome P450 enzyme systems catalyze the β oxidation. Following P450 enzyme-mediated oxidation, fatty acyl CoAs are produced by a series of changes that take place in peroxisomes and/or mitochondria (Pedrini et al., 2007).

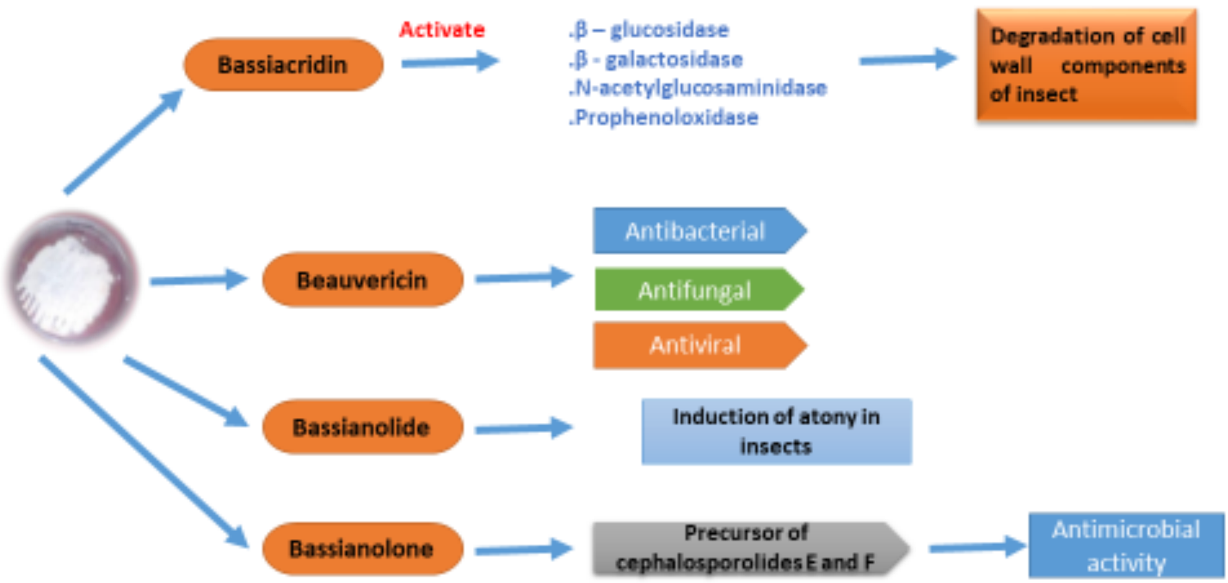

Figure 3: Multifarious roles of various secondary metabolites of *B. bassiana*

Integrated Pest Management Strategies

Globally, agrochemical protection for crops has been recognized for its ability to maintain and increase crop yields. However, the efficacy of natural regulatory mechanisms has been weakened by the widespread and frequently careless usage of these drugs. Problems like pest resistance, the return of secondary pests, including the disruption or breakdown of biological enemy complexes are blamed for this reduction. There is a growing need for more dependable and affordable solutions that put environmental safety first due to worries about how these elements may affect the environment and public safety (Akello et al., 2007).

The employment of fungus, viruses, and bacteria that naturally parasitize insects as agents is one biocontrol tactic. Among the instances are Metarhizium anisopliae, an *Beauveria bassiana*, an insectpathogenic fungus, and pesticide alternatives are becoming more and more popular. However, due to their longer death times than chemical pesticides, the need for huge amounts of inocula, and uneven results with respect to the chemical they compete with, fungi have not performed as well as predicted as biocontrol agents. Unlike viruses and bacteria, which must be consumed in order to spread, pathogenic fungus infect insects by penetrating their cuticle. The proteases, chitinases, & lipases generated by different insect diseases hydrolyze the main cuticle constituents (protein, chitin, and lipids), permitting hyphal penetration (Akello et al., 2008).

An extensive strategy for crop production called IPM (integrated pest management) incorporates a variety of complimentary strategies. These include biological management, companion

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cropping and trapping, cultural manipulation, disinfection, surveying and detecting, using resistant cultivars, and using agricultural herbicides sparingly when needed. Retaining pest populations below those that result in economic harm is the aim of integrated pest management (IPM) (Akello et al., 2009). IPM takes a more comprehensive strategy than conventional, focused-on-individuals, pest-centered methods that mostly rely on chemical pesticides. It takes into account the whole agricultural production system and concentrates on controlling pests as opposed to trying to eradicate them.

Utilizing eco-friendly methods, integrated pest management strategies include the use of entomopathogenic fungus. Because of their unique mode of action and adaptability for large-scale production, these fungi outperform other microbial pesticides generated from bacteria and viruses (Deka et al., 2021). In the global biopesticide market, fungi are the second most widely utilized microorganisms for plant protection (Arnold et al., 2003).

However, abiotic factors that impair the survivability of infectious propagules limit the effectiveness of fungal endomopathogens. A potential solution to these problems is to introduce these microbial populations into plants by inoculation. A certain kind of fungus called a fungal endophyte can exist asymptomatically inside plants for all or a portion of their life cycles. Endophytes were once thought to be inert substances that did not harm or benefit plants. (Barelli et al., 2016).

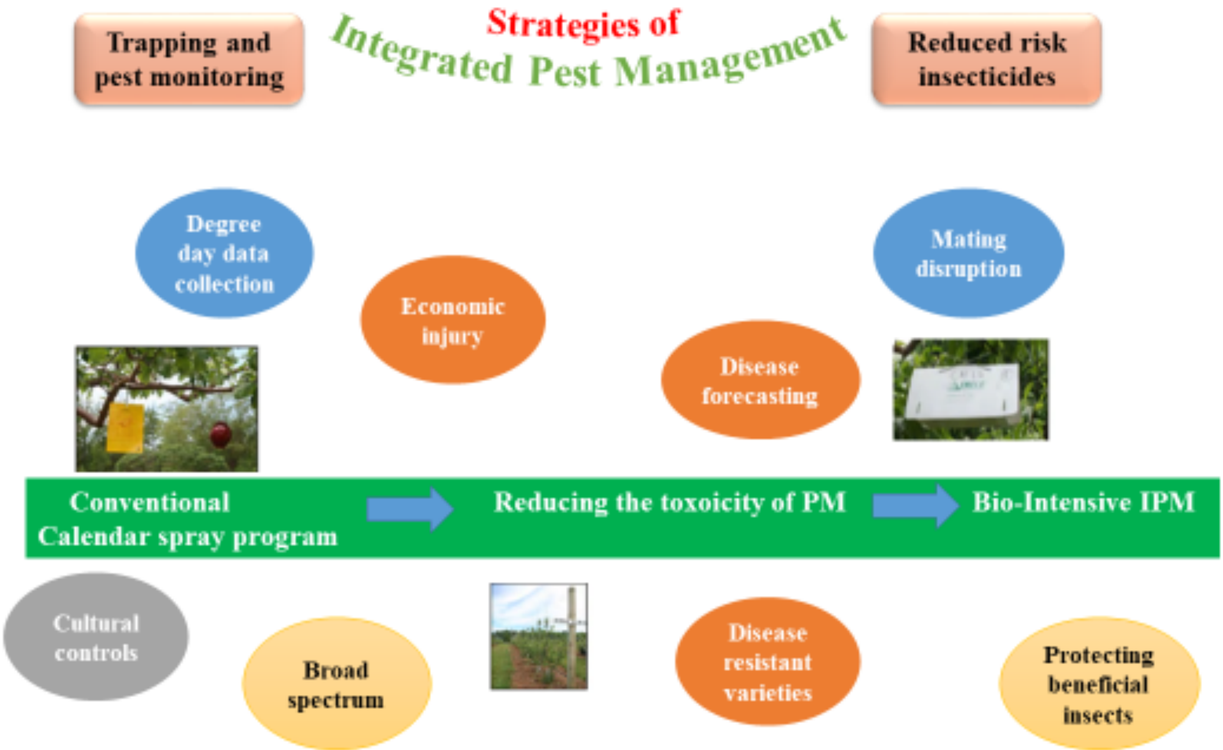

Figure 4: Strategies of integrated pest management

Later, the invisible roles of fungal endophytes in plants were extensively studied. Among these functions are the promotion of plant development and defense against illnesses and pests. These fungal endophytes have the amazing capacity to reduce biotic and abiotic stressors, such as salt, heavy metals, drought, and other harmful substances found in the environment. Additionally, they provide defense against infections, predators, floods, and extremely high or low temperatures (Grabka et al., 2022).

Challenges and Future Directions

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The fungus *Beauveria bassiana* is an entomopathogen that has demonstrated potential as a biocontrol agent against adult hoppers, which are pests that can seriously harm crops. Nevertheless, there are a few obstacles in the way of achieving its full potential effectiveness. This paper examines the current status of research on B. *bassiana* as a biocontrol agent against adult hoppers, talks about the difficulties in determining its effectiveness, and makes recommendations for future study to get over these problems.

Fungi have a relatively modest market share since they require a large volume of inoculum and infect insects more slowly than chemical pesticides. They occasionally exhibit subpar field performance as well, which lessens their effectiveness as biological control agents. The reason behind fungal infections' inconsistent performance in the field is their vulnerability to environmental stressors. Even with more aggressive strains, the host must wait two to five days to be completely eliminated (Craven et al., 2001).

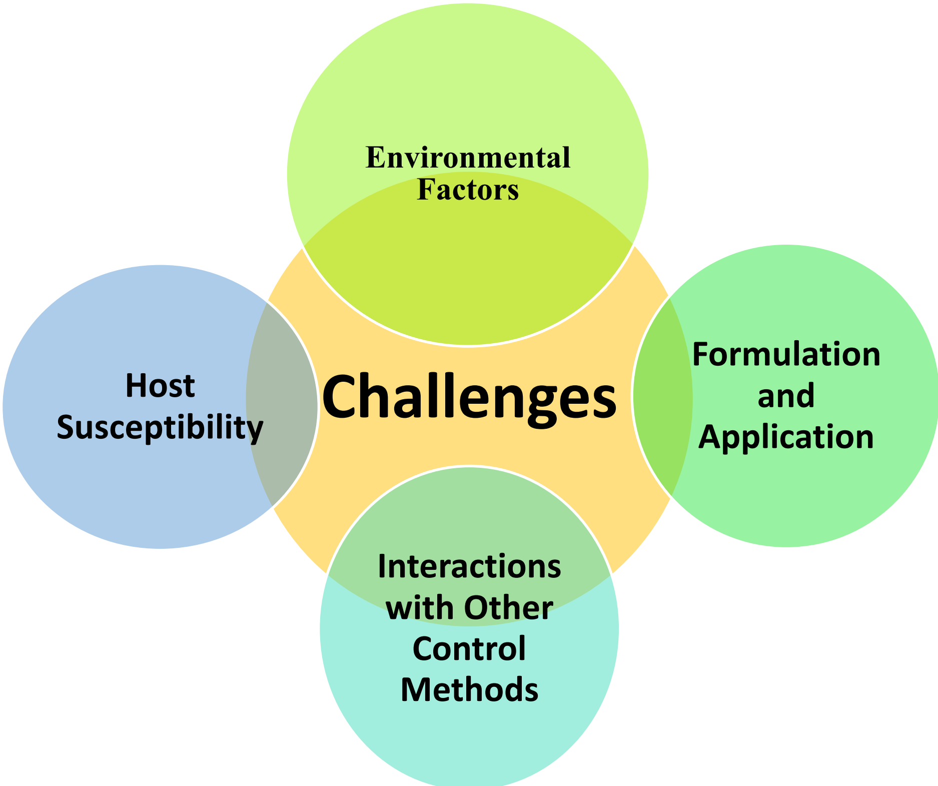

Figure 5: Challenges in Assessing Effectiveness

Conclusion

In conclusion, a number of issues pertaining to host susceptibility, environmental conditions, formulation, application, and interactions with other control approaches must be resolved in order to fully understand the efficacy of *Beauveria bassiana* as a biocontrol agent against adult hoppers. Researchers can overcome these obstacles and fully utilize *B. bassiana* as a fungal biocontrol agent by concentrating on thorough field studies, comprehending host-pathogen interactions, refining formulation and application methods and incorporating *B. bassiana* into integrated pest management strategies.

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