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DERLEME REVIEW

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Recent Advances on the Potential Control of *Rhyzopertha dominica* Fab. (Coleoptera: Bostrichidae)[A]

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Abstract: In agricultural production areas, various factors contribute to yield losses under pre-harvest and post-harvest storage conditions. Among these factors, agricultural pests stand out as a primary concern. For many years, pesticides have been utilized as part of chemical control measures to control pest populations. However, the identification of the toxic effects of pesticides on non-target organisms and particularly, the residue problems affecting humans directly under storage conditions have led to restrictions on pesticide use. This has prompted the emergence of alternative pest control methods. This review focuses on recent studies related to potential control methods that have shown promising results as alternatives to pesticides in the management of *Rhyzopertha dominica*, a significant stored-product pest.

Keywords: Amorphous silica, diatomaceous earth, entomopathogenic nematodes, lesser grain borer.

[A] This study does not require ethics committee approval. The article has been prepared in accordance with research and publication ethics.

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Rhyzopertha dominica Fab. (Coleoptera: Bostrichidae)'nın Potansiyel Kontrolüne İlişkin Son Gelişmeler

Öz: Tarımsal üretim yapılan alanlarda hasat öncesi ve hasat sonrası depolama koşullarında, çeşitli faktörler ürünlerdeki verim kayıplarına neden olmaktadır. Bunlar arasında ise tarımsal zararlılar birincil faktör olarak öne çıkmaktadır. Zararlılarla mücadelede uzun yıllardır kimyasal mücadele kapsamında pestisitler kullanılmaktadır. Ancak, pestisitlerin hedef dışı organizmalar üzerindeki toksik etkileri ve depo koşullarında insan sağlığını doğrudan etkileyen kalıntı problemleri nedeniyle, pestisit kullanımına getirilen kısıtlamalar alternatif mücadele yöntemlerinin önem kazanmasına neden olmuştur. Bu derleme, önemli bir depolanmış ürün zararlısı olan *Rhyzopertha dominica*'nın mücadelesinde kullanılan pestisitlere alternatif olabilecek son yıllarda umut vaad eden sonuçlar elde etmiş olan potansiyel kontrol yöntemleriyle ilgili son çalışmalara odaklanmaktadır.

Anahtar Kelimeler: Amorf silika, biyolojik mücadele, diatom toprağı, entomopatojen nematodlar, ekin kambur biti.

Introduction

In agricultural production areas, numerous factors cause yield losses both before and after harvest (Oerke, 2006; Bütüner and Susurluk, 2023a; Bütüner et al., 2024a). One of the primary factors contributing to these losses is pests. Agricultural pest can inflict damage on plants in field conditions before harvest and can also lead to significant yield post-harvest losses in storage conditions (Dhaliwal et al., 2010; Culliney, 2014; Sánchez-Bayo, 2021; Bütüner et al., 2023; Bütüner and Susurluk, 2023b). Among agricultural pests that cause substantial yield losses in storage facilities, *Rhyzopertha dominica* Fab. (Coleoptera: Bostrichidae) is one of the key pest (Emekci et al., 2004; Bütüner et al., 2024a).

Rhyzopertha dominica is indeed a notable pest in the realm of grain storage. This species presents a major risk to stored grains like corn, wheat, rice, and sorghum in numerous regions globally (Yüksel et al., 2019). Both adult and larvae of *R. dominica* contribute to the deterioration of stored grain quality as they feed (Perez-Mendoza et al., 1998; Mahroof et al., 2010; Arthur et al., 2012; Edde, 2012; Bütüner et al., 2024a). The life cycle of *R. dominica* begins with adult females laying eggs shortly after mating. Typically, each female can lay between 300 to 500 eggs during her reproductive period (Chaudhry and Price, 1992; Deshwal et al., 2018; Bütüner et al., 2024a). Once the eggs hatch, the larvae emerge and begin their destructive feeding habits. They penetrate grains or consume flour and small particles that escape from holes created by adults. Adult *R. dominica* also exacerbates the damage by entering grains to feed and continue developing. This continuous cycle of egg laying, larval feeding, and adult feeding allows *R. dominica* to potentially complete 3 to 4 generations per year under favorable conditions (Beckett and Morton, 2003; Majeed et al., 2015; Javanmard et al., 2023).

Pesticides have been employed for many years as a chemical control method to manage pests, and their use persists to this day (Sabzevari and Hofman, 2022; Ore et al., 2023; Bütüner et al., 2024b). However, recent European Union (EU) decisions have led to restrictions on pesticide use in agricultural production areas, particularly in storage facilities for pest management (Marchand and Robin, 2019; Dede et al., 2022). Some of the main reasons for these restrictions are the harmful effects pesticides on non-target organisms and the residues they leave on stored products. (Zhang et al., 2011; Malhotra and Aman, 2024; Sood, 2024). This situation has increased the need to prioritize alternative pest management methods over chemical control.

Recently, many studies have focused on controlling *R. dominica* in storage conditions. These studies seek to develop strategies to minimize yield losses from *R. dominica* in storage facilities and manage pest populations effectively. Researches focusing on biological control methods, the use of different compounds, and substances such as diatomaceous earth and amorphous silica have taken significant steps in identifying effective strategies against this pest (Canhilal, 2016; Yüksel et al., 2019; Bütüner et al., 2024; Cao et al., 2024; Ertürk et al., 2024; Mortazavi et al., 2024). In this context, recent years have seen a review of promising scientific studies aimed at potential control alternatives to chemical control for *R. dominica*.

Potential Control of *R. dominica* by Synthetic Compounds

Rhyzopertha dominica, known as the lesser grain borer, shows varying responses to different compounds (Kerbel et al., 2024; Mostafa et al., 2024; Salman et al., 2024). Cao et al. (2024) found that different volatile substances from grains triggered attractant responses, with wheat proving particularly effective. Salman et al. (2024) demonstrated that combining essential oils from cinnamon, cumin, dill, rosemary, lavender, and garlic with gamma radiation resulted in toxic effects on adults. Additionally, Çılığın et al. (2024) suggested that laurel and mint could potentially be lethal to *R. dominica*. Iqbal et al. (2024) observed that an extract from *Moringa oleifera* (Brassicales: Moringaceae) leaves caused up to 81% mortality in *R. dominica*, indicating its potential as a biological pesticide. Similarly, Ertürk et al. (2024) tested compounds such as disodium octaborate tetrahydrate, ammonium tetrafluoroborate, sodium metaborate tetrahydrate, and calcium metaborate for controlling *R. dominica*, finding that disodium octaborate tetrahydrate achieved 100% mortality. These studies underscore the growing research focus on this topic in recent years (Kerbel et al., 2024; Mahmood et al., 2024; Mostafa et al., 2024; Salman et al., 2024).

Potential Control of *R. dominica* by Entomopathogenic Nematodes

Entomopathogenic nematodes (EPNs) have become increasingly popular for controlling storage pests in recent years (Bütüner and Susurluk, 2023a; Nawab and Javed, 2023; Yüksel et al., 2023; Vargas et al., 2024; Yaraşır et al., 2024). However, most studies have been limited to laboratory conditions. Additional research is required to assess the effectiveness of various EPN species against these pests, particularly under warehouse conditions, to

facilitate their practical application. Recent research has investigated the potential of using EPNs to control *R. dominica*. Bütüner et al. (2024a) applied various doses of *Heterorhabditis bacteriophora* (Rhabditida: Heterorhabditidae) HBH hybrid strain, *Steinernema carpocapsae* (Rhabditida: Steinernematidae) TUR-S4 isolate, *Steinernema feltiae* (Rhabditida: Steinernematidae) TUR-S3, and S-Bilecik isolates to adult *R. dominica*, achieving mortality rates of up to 93.33%. These results indicate promising potential for controlling *R. dominica*. However, for effective utilization in warehouses, the integration of EPN traps, which are either mechanized or simply designed, with attractants that can have a attractive effect on pests, could potentially be practical and effective in the control of warehouse pests.

Potential Control of *R. dominica* by Diatomaceous Earth and Amorphous Silica

In recent years, studies have shown the effectiveness of diatomaceous earth mixed with grains in laboratory experiments against storage pests (Milosavljević et al., 2024; Susurluk and Bütüner, 2024; Wakil et al., 2024). Mortazavi et al. (2024) conducted a study where instead of mixing diatomaceous earth with grains, they applied it directly onto concrete surfaces, achieving mortality rates of up to 90% on adult *R. dominica*. These results suggest promising alternatives to pesticides, especially in empty warehouse applications. Similarly, Manivannan et al. (2024) investigated two different samples of amorphous silica applied to wheat grains against *R. dominica*, observing mortality rates exceeding 90% following prolonged exposure. In recent years, researchers have conducted studies to evaluate the efficacy of diatomaceous earth and amorphous silica on *R. dominica* (Baliota et al., 2024; Wakil et al., 2024).

Conclusion

Pesticides have long been used to control pests. However, due to their residues, the direct application of pesticides onto products enters the consumption chain, especially under storage conditions. Consequently, restrictions imposed on pesticide usage highlight the importance of eco-friendly alternative methods for pest management (Sabzevari and Hofman, 2022; Ore et al., 2023; Bütüner et al., 2024b). Within the scope of this study, recent studies that focused on alternative methods in the control of *R. dominica* have been reviewed. Specifically, the design and integration of specific traps in storage facilities for the effective use of organisms such as EPNs and compounds like diatomaceous earth, and amorphous silica are considered highly effective in potential control of storage pests such as *R. dominica*. In this context, the authors are working on the design of a trap intended for potential use in controlling storage pests such as *R. dominica*.

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