API-VECTORING: ENHANCING CROP POLLINATION AND PRECISION BIOCONTROL

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ABSTRACT

EEntomovectoring combines pollination and biocontrol, utilized globally on over 30 million hectares in 2015. Bumblebee commercialization alone generated €55 million in 2004. This "entomovectoring technology" uses insects to transfer pollen and biocontrol agents between flowers. Honeybees and bumblebees are primary vectors, but local species are advantageous in areas without such facilities. International Biological Control Agent registration guidelines are crucial for timely benefits. Api-Vectoring reduces labor costs and non-target exposure, enhancing environmental and human health. This innovation revolutionizes agriculture by maximizing ecological services and reducing chemical reliance.

KEYWORDS: bees, biological control, disease-causing pathogens, pollination, vectors

INTRODUCTION

Pollinators and biocontrol agents are extensively utilized worldwide, with over 30 million hectares treated with invertebrate and microbial agents in 2015 (Van Lenteren *et al.*, 2018). The commercialization of bumblebees alone generated €55 million for the pollination industry in 2004 (Velthuis & van Doorn, 2006). Integrating these two international functions through entomovectoring enhances pollination and optimizes biocontrol agent application. This innovative system mimics nature by leveraging insects' natural abilities to transfer pollen and microorganisms between flowers, adapted for commercial pollination and biocontrol agent transport. Hokkanen and Menzler-Hokkanen termed this technique as 'entomovectoring technology.' While it holds potential for market expansion, it raises new considerations for international risk assessment and shipping protocols. During transportation vectors and biocontrol agents are packed separately but follow standard pollinator transport procedures and do not require additional management. In 1992, honeybees were used to transfer the fungus *Gliocladium roseum*, a biocontrol agent to protect strawberry plants from *Botrytis cinerea* (Peng *et al.*, 1992). This novel approach combines pollination and pollination services by utilizing pollinators such as honeybees to transport biocontrol agents that result in increased seed production and defense against plant pathogens. It reduces the cost of labour and time while reducing exposure to non-target organisms. Moreover, entomovectoring circumvents the use of harmful chemicals, promoting environmental and human health. Thus, entomovectoring aids in revolutionizing modern agriculture by capitalizing on the ecological services provided by insects while minimizing reliance on chemical interventions.

HOW DOES AN ENTOMOVECTORING WORK?

The process involved mass-producing microbial biocontrol agents by selecting specific strains of microorganisms. These agents were then multiplied on a chosen substrate, air-dried, and mixed with talc or cornmeal after which any solid debris was removed. The bee colonies consisting of a queen and around 5000 workers were used to contaminate with microbial agents. The selected colonies were acclimated and provided with honey and water. Later, an inoculum dispenser was devised to introduce the biocontrol agent to the bees. This dispenser was designed to fit within the hive, allowing bees to pass through the inoculum before leaving the hive. Inoculum acquisition by bees was studied using dispensers placed within the hives. Bees were exposed to the prepared inoculum, and samples were taken to assess if the bees had acquired the biocontrol agent. Microscopy techniques were employed to examine some bees for any adhering spores. The contaminated bee hives were subjected to fields or greenhouses for pollination services (Peng *et al*., 1992).

DIFFERENT TYPES OF POLLINATORS AS VECTORS

A diverse array of pollinators were harnessed as vectors for transferring biological control agents, encompassing a range of species including honey bees, bumble bees, leaf cutter bees, mason bees, and stingless bees. Honey bees emerged as prominent vectors across multiple continents, including North America, Europe, South America, and Asia. Their widespread distribution and effectiveness made them valuable assets in the dissemination of biological control agents. In North America, bumble bees, specifically *Bombus impatiens*, played a significant role as vectors. Meanwhile, in Europe and Korea, *Bombus terrestris* took center stage for similar purposes. In Canada, the leafcutter bee *Megachile rotundata* contributed to the dissemination of biological control agents. Similarly, in Italy, the mason bee *Osmia cornifrons* proved to be an effective vector in agricultural settings. In Latin America, stingless bees were enlisted as vectors, showcasing their unique ability to contribute to the transfer of biological control agents within the region's diverse ecosystems (Kevan *et al.*, 2008).

INTRICATE INTERACTIONS WITHIN ENTOMOVECTORING TECHNOLOGY

The multifaceted interactions within entomovectoring technology involve illustrating the interconnected relationships between different components such as pollinators, Biological control agents, plants, pests/pathogens, and the environment to achieve sustainable pest management and crop production.

Selection of vector: The proper application of microbial biological control agents onto flowers is essential for the entomovectoring system's effectiveness. Choosing the right pollinator as a vector depends on factors such as crop type, visitation rate, and its ability to disperse biological control agents (Mommaerts & Smagghe, 2011). Honeybees and bumblebees are commonly selected due to their year-round availability and effectiveness. For instance, *Apis* and *Bombus* workers exhibit differences in pollen deposition and removal due to distinct foraging behaviours. Certain plant-pollinator associations reveal that the Asteraceae family attracts honeybees and wild bees (Maccagnani *et al.*, 2020). while Brassicaceae plants are more favoured by honeybees over solitary bees and bumblebees. Other species like solitary bees have also been utilized. Plans for using stingless bees in Latin America are underway, but further research and development are needed before their commercial use in entomovectoring.

Selection of a biocontrol agent: The selection of a biocontrol agent had several critical factors. Firstly, it's crucial to check the genetic stability and can effectively control pests or pathogens even at low concentrations. Additionally, it should have modest nutrient requirements for easier multiplication and application across diverse agricultural environments. The agent must also demonstrate resilience to adverse environmental conditions to maintain its effectiveness in different environments. Resistance to pesticides and the ability to not harm the host plant is vital to prevent unintended consequences. Furthermore, it's imperative that the biocontrol agent poses no risks to human health and can be easily stored and distributed. Its efficacy against both aerial and foliar pests and pathogens ensures comprehensive protection. Safety for both the pollinator and the crop is paramount, along with the ability to thrive within flower conditions, where transmission primarily occurs. Adhering to these criteria ensures the selection of a suitable biocontrol agent that effectively manages pests or pathogens while upholding ecosystem and human health.

Transport of a biocontrol agent: Advancing entomovectoring technology involves ensuring vectors acquire sufficient microbial control agents (MCA) for optimal transport to flowers. Many commercial MCA formulations need improvement for vectoring. Dispensers must be designed to ensure vector safety, adequate MCA loading, and refilling intervals of over a day. Various dispenser types have been developed over two decades, categorized into one-way and two-way dispensers. While one-way dispensers were found to be less suitable due to low MCA acquisition, altered foraging behaviour, and the need for daily refills. However, an exception exists, like the over-and-under one-way dispenser for bumblebees. Two-way dispensers, including the Tray-, Peng-, Triwaks-, Gross-, and Houle dispensers, showed increased vector loading and effective disease/pest control, particularly in honey bees. Among these, the "BeeTreat" dispenser is commercially available (Hokkanen *et al.*, 2015). Other vectors like bumblebees and mason bees require suitable two-way dispenser designs. The effectiveness of MCA acquisition and transportation is enhanced by minimizing loss during flight (Kevan et al. 2008; Mommaerts and Smagghe, 2011). However, carriers used in MCA formulations must ensure the stability of the MCA and the safety of the vector. Certain carriers, like talc, can negatively impact MCA growth and honey bee brood, leading to grooming behaviour due to irritation (Israel and Boland 1993; Pettis *et al.*, 2004). In contrast, carriers like corn flour, bentonite, corn starch, and polystyrene beads are considered safe and effective. Particle size and moisture content of carriers also influence honey bee loading, with smaller particles being more suitable for effective acquisition (Al-Mazarati *et al.* 2007).

CONCLUSION

Api-Vectoring offers a promising approach to simultaneously enhance crop pollination and precision biocontrol. By harnessing the synergies between pollination and antipathogenic properties. While honeybees and bumblebees are primary candidates for entomovectoring, exploring local species can offer long-term benefits, particularly in regions lacking rearing facilities or research. Investing in local species not only mitigates transport challenges but also fosters pollinator biodiversity and improves system efficiency. Api-Vectoring holds great promise for sustainable agriculture and ecosystem health.

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How to Cite:

Bindu Gudi Ramakrishna and Jasti Sri Vishnu Murthy (2024). Api-vectoring: enhancing crop pollination and precision biocontrol. Leaves and Dew Publication, New Delhi 110059. *Agri Journal World*, 4(6):7-11.

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