NEW ERA AGRICULTURE MAGAZINE

Entomovectoring: Harnessing Pollinators for Sustainable Crop Protection and Disease Management

G Balraj*[1,2], Rabindra Prasad[1], Koosi Sai Thilak[2], and Kamsali Pruthvi Raju[1,3],

Abstract: -

Entomovectoring is an innovative agricultural strategy that employs pollinators, such as honey bees and bumblebees, to deliver microbial control agents (MCAs) directly to crop flowers. This method has been successfully applied to manage major diseases, including fire blight in apple and grey mould in strawberry, by transferring biocontrol agents like *Bacillus subtilis* and *Trichoderma harzianum* to receptive flower parts. Entomovectoring integrates pollination with biological disease control, offering a sustainable, eco-friendly alternative to chemical pesticides. Its potential extends to organic and regenerative farming, diverse crops, and climate-smart agriculture, promoting crop health, productivity and environmental sustainability.

Key words: Entomovectoring, Honey bees, Bumblebees etc.

1. Introduction:

In agricultural and horticultural crops pollination is foremost for establishment of fruitful fruit setting which is of high economic significance with an annual worldwide value reported to be 153 billion euro (Gallai *et al.* 2009). Since their origin, insects and plants have co-evolved to mutually benefit one another, while plant pathogens have simultaneously adapted to enhance their dispersal. The spread of plant diseases, whether over short or long distances, is influenced not only by abiotic factors but also by insect vectors such as pollinators. Pollinators are particularly recognized for their ability to transmit viruses as well as fungal and bacterial spores alongside pollen (Card *et al.*,

G Balraj*[1,2], Rabindra Prasad[1], Koosi Sai Thilak[2], and Kamsali Pruthvi Raju[1,3],

[1]Department of Entomology, Dr. Rajendra Prasad Central Agricultural University, Pusa (848 125), India

[2]Department of Entomology, N. M. College of Agriculture, Navsari Agricultural University Navsari (396 450), India

[3]Department of Genetics and Plant Breeding, Indian Agricultural Research Institute, New Delhi (110 012), India

2007). This understanding has given rise to the concept of using pollinators as natural vectors in an environmentally sustainable strategy to disseminate biological control agents against plant pathogens and insect pests directly into crop flowers (Peng *et al.*, 1992). Thus, pollinators serve a dual function: they provide vital pollination services while also contributing to innovative plant protection strategies.

2. Mechanism of Entomovectoring:

Honeybees play a dual role in agriculture by serving as both pollinators and carriers of beneficial microbial control agents (MCAs). During foraging, bees naturally visit flowers to collect nectar and pollen. In the process, they acquire MCAs from specialized dispensers and subsequently transfer them, along with pollen grains, to successive flowers. Once deposited, these microbial agents act against harmful plant pathogens and insect pests. This mechanism not only enhances pollination efficiency but also provides an eco-friendly approach to crop protection, offering a sustainable alternative to chemical pesticides while supporting plant health and productivity through biological control.

3. Insect Vectors Used in Entomovectoring

3.1 Honey bees (*Apis mellifera*):

Honey bees are the most commonly used insect vectors in entomovectoring

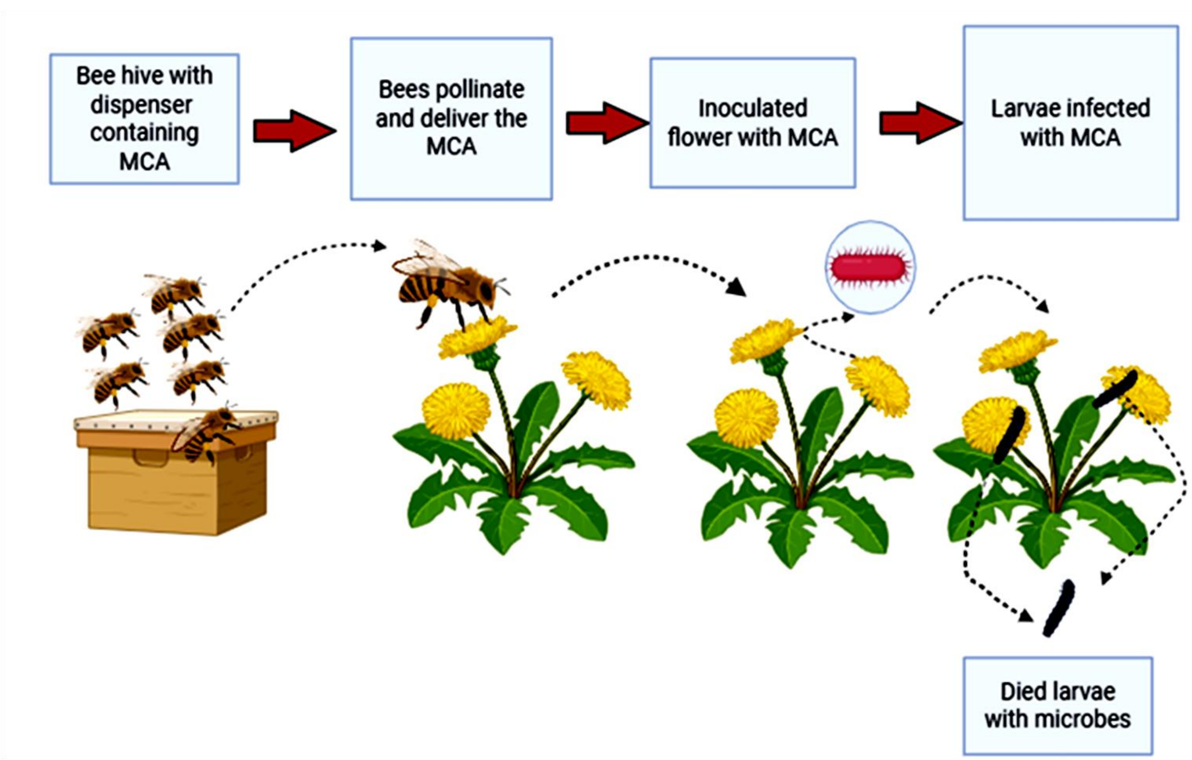

Fig.1. Schematic illustration of the entomovectoring mechanism (created with Biorender online software, source: https://www.biorender.com/).

because of their wide distribution, large colony size and predictable foraging behavior. They are social insects with tens of thousands of workers that forage intensively for nectar and pollen. Their hairy bodies make them excellent carriers of MCAs, which they can transfer to flowers during pollination. Beekeeping techniques for colony management and transport are well established, making their use in crop protection relatively easy. Honey bees have been fruitfully used to spread the beneficial microbial control agents such as *Trichoderma* spp, *Clonostachys rosea*, and *Gliocladium* spp. to control fungal pathogens like *Botrytis cinerea* in crops including strawberry, raspberry, apple, and sunflower. The dual role of honey bees in pollination and biological disease control increases crop yield and quality. However, their activity is sensitive to adverse weather conditions and pesticide exposure, and their large-scale use carries the risk of unintentionally spreading harmful pathogens if colonies are infected.

3.2 Bumblebees (*Bombus spp.*)

Bumblebees (*Bombus* spp.) also play an important role as vectors in entomovectoring, particularly in greenhouse and temperate field conditions. Unlike honey bees, bumblebees form smaller colonies of 50 to 400 individuals but are highly efficient pollinators due to their robust, hairy bodies and unique ability to perform buzz pollination, which is especially beneficial for crops such as tomato, blueberry, and pepper. They are well adapted to foraging in cooler temperatures, cloudy weather, and low-light conditions, making them valuable in environments where honey bees are less active. Bumblebees are widely used in greenhouse crops like tomato and strawberry to deliver antagonistic fungi such as *Clonostachys rosea* for the control of Botrytis cinerea. Their smaller colony size allows for easier handling and targeted delivery of microbial inoculants, though this also limits their coverage compared to honey bees. Additionally, commercial rearing of bumblebees is more expensive, and their colonies have shorter lifespans, making them less suitable for long-duration crops.

Honey bees and bumblebees offer complementing benefits as entomovectors. Honey bees are more suited for large-scale, open-field crops due to their strong colonies and wide foraging range, whereas bumblebees thrive in greenhouses and cooler regions where honey bee activity is low. Their combined use improves the efficacy of entomovectoring by guaranteeing efficient pollination and consistent delivery of microbial agents for crop protection.

4. Management of diseases using entomovectoring:

4.1 Fire blight in apple:

Fire blight, caused by *Erwinia amylovora*, is a highly destructive disease in apple. Biological control strategies have demonstrated that both *Apis mellifera* and *Osmia cornuta* can serve as effective secondary carriers of the biocontrol agent *Bacillus subtilis* strain BD170 on apple flowers, thereby contributing to the management of this disease. Among the two pollinator species, *O. cornuta* showed superior efficiency in depositing the biocontrol agent onto the most receptive flower parts. Field trials further confirmed that pollinators are capable of transferring the biocontrol agent from treated flowers to newly opened flowers, sustaining colonization for several days. These results underscore the considerable potential of employing pollinators as natural vectors for biocontrol agents within integrated disease management programs in apple orchards (Maccagnani *et al*., 2006).

4.2 Gray mold in strawberry:

Botrytis cinerea, the causal agent of grey mould, poses a significant threat to strawberry and other crops, demonstrated that honey bees can effectively disseminate *Trichoderma harzianum* T39 to control *B. cinerea* in strawberry under field conditions. Using the 'Triwaks' dispenser, bees successfully distributed the biocontrol agent across the crop, achieving effective colonization even at distances up to 200 meters from the hives. Grey mould incidence was best managed in bee-visited plots, particularly under low to medium disease pressure, whereas high disease levels exceeded the control capacity of both chemical and biological treatments (Shafir *et al*., 2006).

5. Future Prospects of Entomovectoring in Plant Protection

Entomovectoring offers promising opportunities for sustainable and precision crop protection. Its potential in organic and regenerative farming is particularly notable, as it provides a natural, chemical-free method for delivering biocontrol agents, aligning with the goals of reducing synthetic pesticide use and promoting soil and ecosystem health. The expansion to other crops and regions presents another significant avenue, as pollinator-mediated delivery systems can be adapted to a wide range of horticultural and field crops beyond strawberries and tomatoes, including grapes, cucurbits, and orchard crops, across diverse agroclimatic zones. Moreover, entomovectoring can play a key role in climate-smart agriculture, enhancing resilience against emerging pathogens and reducing the environmental footprint of crop protection by integrating pollination services with disease management. Continued research and technological improvements, such as optimized dispensers and formulation of biocontrol agents, will further enhance the effectiveness and adoption of entomovectoring in modern agriculture.

Conclusion:

Entomovectoring is an effective and sustainable crop protection strategy that combines pollination with targeted delivery of microbial control agent. Honey bees and bumblebees effectively carry microbial control agent to flowers, preventing diseases like fire blight and grey mould. The technique promotes organic and regenerative farming, increases crop output and quality and may be applied to a variety of crops and areas. With additional technological advancements in dispensers and microbial formulations, entomovectoring has the potential to become an important component of integrated disease management methods, contributing to ecologically friendly and climate-smart farming practices.

References:

1. Card, S. D., Pearson, M. N., & Clover, G. R. G. (2007). Plant pathogens transmitted by pollen. *Australasian Plant Pathology*, *36*(5), 455-461.
2. Gallai, N., Salles, J. M., Settele, J., & Vaissière, B. E. (2009). Economic valuation of the vulnerability of world agriculture confronted with pollinator decline. *Ecological economics*, *68*(3), 810-821.
3. Maccagnani, B., Bazzi, C., Biondi, E., Tesoriero, D., & Maini, S. (2004, July). Potential of Osmia cornuta as a carrier of antagonist bacteria in biological control of fire blight: a comparison with *Apis mellifera*. In X International Workshop on Fire Blight 704 (pp. 379-386).
4. Peng, G., Sutton, J. C., & Kevan, P. G. (1992). Effectiveness of honey bees for applying the biocontrol agent *Gliocladium roseum* to strawberry flowers to suppress Botrytis cinerea. *Canadian Journal of Plant Pathology*, *14*(2), 117-129.
5. Shafir, S., Dag, A., Bilu, A., Abu-Toamy, M., & Elad, Y. (2006). Honey bee dispersal of the biocontrol agent *Trichoderma harzianum* T39: effectiveness in suppressing *Botrytis cinerea* on strawberry under field conditions. *European Journal of Plant Pathology*, *116*(2), 119-128.